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ABSTRACT

This document is intended to help education and training institutions deliver the Machine Tool Advanced Skills Technology (MAST) curriculum to a variety of individuals and organizations. MAST consists of industry-specific skill standards and model curricula for 15 occupational specialty areas within the U.S. machine tool and metals-related industries. This volume provides the MAST standards and curriculum for the automated equipment technician (computer-integrated manufacturing, CIM) specialty area. It is organized in the following sections: (1) a profile of San Diego City College, the development center that produced these standards and curriculum; (2) an automated equipment technician competency profile of job duties and tasks; (3) a technician duty, task, and subtask outline; (4) a course curriculum outline and course descriptions; (5) a technical workplace competencies and course crosswalk; and (6) a Secretary's Commission on Achieving Necessary Skills (SCANS) proficiencies course crosswalk. Individual syllabi for the following courses are provided: Manufacturing Metrics and Calculations; Teamwork Skills; Print Reading and Symbology; Manufacturing Processes; Industrial Programming Theory; Industrial Electronics/Electricity; Motion Control/Servo Systems; Fluid Power Technology; Programmable Logic Controllers; Industrial Machine Technology; and Flexible Manufacturing Systems/Robotics. Components of each syllabus are as follows: lecture, lab, and credit hours; course description; prerequisites; course objectives; required course materials; method of instruction; course objectives: technical competencies; and course objectives: SCANS competencies. Appendixes contain the individual competency profiles for each company surveyed by the MAST development center and narrative of the pilot program for this occupational specialty. (YLB)

ED 401 444

Machine Tool
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Skills
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COMMON GROUND: TOWARD A STANDARDS-BASED TRAINING SYSTEM FOR THE U.S. MACHINE TOOL AND METAL RELATED INDUSTRIES

VOLUME 14

AUTOMATED EQUIPMENT TECHNICIAN (CIM)

of
a 15 volume set of Skills Standards
and
Curriculum Training Materials for the
PRECISION MANUFACTURING INDUSTRY

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1948

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COMMUNITY COLLEGE

Texas State
Technical College
Waco

*M*achine Tool *A*dvanced *S*kills *T*echnology Program

MAST

VOLUME 14

AUTOMATED EQUIPMENT TECHNICIAN (CIM)

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- U.S. Department of Education, Office of Vocational & Adult Education
- MAST Consortia of Employers and Educators

MAST DEVELOPMENT CENTERS

Augusta Technical Institute - Itawamba Community College - Moraine Valley Community College - San Diego City College (CACT) - Springfield Technical Community College - Texas State Technical College

INDUSTRIES

AB Lasers - AIRCAP/MTD - ALCOA - American Saw - AMOCO Performance Products - Automatic Switch Company - Bell Helicopter - Bowen Tool - Brunner - Chrysler Corp. - Chrysler Technologies - Conveyor Plus - Darr Caterpillar - Davis Technologies - Delta International - Devon - D. J. Plastics - Eaton Leonard - EBTEC - Electro-Motive - Emergency One - Eureka - Foster Mold - GeoDiamond/Smith International - Greenfield Industries - Hunter Douglas - Industrial Laser - ITT Engineered Valve - Kaiser Aluminum - Krueger International. - Laser Fare - Laser Services - Lockheed Martin - McDonnell Douglas - Mercury Tool - NASSCO - NutraSweet - Rapistan DEMAG - Reed Tool - ROHR, International - Searle - Solar Turbine - Southwest Fabricators - Smith & Wesson - Standard Refrigeration - Super Sagless - Taylor Guitars - Tecumseh - Teledyne Ryan - Thermal Ceramics - Thomas Lighting - FMC, United Defense - United Technologies Hamilton Standard

COLLEGE AFFILIATES

Aiken Technical College - Bevil Center for Advanced Manufacturing Technology - Central Florida Community College - Chicago Manufacturing Technology Extension Center - Great Lakes Manufacturing Technology Center - Indiana Vocational Technical College - Milwaukee Area Technical College - Okaloosa-Walton Community College - Piedmont Technical College - Pueblo Community College - Salt Lake Community College - Spokane Community College - Texas State Technical Colleges at Harlington, Marshall, Sweetwater

FEDERAL LABS

Jet Propulsion Lab - Lawrence Livermore National Laboratory - L.B.J. Space Center (NASA) - Los Alamos Laboratory - Oak Ridge National Laboratory - Sandia National Laboratory - Several National Institute of Standards and Technology Centers (NIST) - Tank Automotive Research and Development Center (TARDEC) - Wright Laboratories

SECONDARY SCHOOLS

Aiken Career Center - Chicopee Comprehensive High School - Community High School (Moraine, IL) - Connally ISD - Consolidated High School - Evans High - Greenwood Vocational School - Hoover Sr. High - Killeen ISD - LaVega ISD - Lincoln Sr. High - Marlin ISD - Midway ISD - Moraine Area Career Center - Morse Sr. High - Point Lamar Sr. High - Pontotoc Ridge Area Vocational Center - Putnam Vocational High School - San Diego Sr. High - Tupelo-Lee Vocational Center - Waco ISD - Westfield Vocational High School

ASSOCIATIONS
American Vocational Association (AVA) - Center for Occupational Research and Development (CORD) - CIM in Higher Education (CIMHE) - Heart of Texas Tech-Prep - Midwest (Michigan) Manufacturing Technology Center (MMTC) - National Coalition For Advanced Manufacturing (NACFAM) - National Coalition of Advanced Technology Centers (NCATC) - National Skills Standards Pilot Programs - National Tooling and Machining Association (NTMA) - New York Manufacturing Extension Partnership (NYMEP) - Precision Metalforming Association (PMA) - Society of Manufacturing Engineers (SME) - Southeast Manufacturing Technology Center (SMTC)

MAST PROJECT EVALUATORS
Dr. James Hales, East Tennessee State University and William Ruxton, National Tooling and Machine Association (NTMA)

SPECIAL RECOGNITION
Dr. Hugh Rogers recognized the need for this project, developed the baseline concepts and methodology, and pulled together industrial and academic partners from across the nation into a solid consortium. Special thanks and singular congratulations go to Dr. Rogers for his extraordinary efforts in this endeavor.

This report is primarily based upon information provided by the above companies, schools and labs. We sincerely thank key personnel within these organizations for their commitment and dedication to this project. Including the national survey, more than 3,000 other companies and organizations participated in this project. We commend their efforts in our combined attempt to reach some common ground in precision manufacturing skills standards and curriculum development.

This material may be found on the Internet at **http://machinetool.tstc.edu**

CATALOG OF 15 VOLUMES

VOLUME 1	EXECUTIVE SUMMARY STATEMENT OF THE PROBLEM MACHINE TOOL ADVANCED SKILLS TECHNOLOGY PROJECT PROJECT GOALS AND DELIVERABLES PROJECT METHODOLOGY PROJECT CONCLUSIONS AND RECOMMENDATIONS APPENDICES
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VOLUME 3	MACHINING - CORE COURSES (MAC)
VOLUME 4	MANUFACTURING ENGINEERING TECHNOLOGY (MET)
VOLUME 5	MOLD MAKING (MLD)
VOLUME 6	WELDING (WLD)
VOLUME 7	INDUSTRIAL MAINTENANCE (IMM)
VOLUME 8	SHEET METAL (SML) AND COMPOSITES (COM)
VOLUME 9	TOOL AND DIE (TLD)
VOLUME 10	COMPUTER-AIDED DRAFTING AND DESIGN (CAD)
VOLUME 11	COMPUTER-AIDED MANUFACTURING AND ADVANCED CNC (CNC)
VOLUME 12	INSTRUMENTATION (INT)
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AUTOMATED EQUIPMENT TECHNOLOGY

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FOREWORD

Important changes in machine tool technology, especially the use of Computerized Numerical Control Machines and Robots to automate processes that were traditionally craft-based and required great skill, have altered the size and scope of machine tool and metal-related manufacturers. The flexibility and reliability of modern automated machine technologies allows a company to operate efficiently with only a handful of machines and many fewer employees, yet produce many product variations at high quality and low cost. The new capability is driving demand for multi-skilled technicians who can operate, program, diagnose and repair the new automated systems and manufacturing processes that drive our industries, including flexible manufacturing systems, CNCs, robots, and process controllers. This requires a set of skills once divided among separate trades such as electronics technicians, electrical technicians, and mechanical technicians.

A small number of educational institutions, led by two-year colleges, have begun to anticipate and address the need for new types of training arising from the above developments. Attempting to create an educational environment that breaks with tradition and explores new educational methods, they have launched training programs designed to integrate a broad array of skills and tasks in a single individual. With their tradition of vocational training and responding to the needs of the business market, the community colleges were quick to recognize that small companies cannot afford to hire several people to do different jobs and that employees must handle more of the duties once reserved for workers with more education. The Automated Equipment Technician/CIM training program, begun by San Diego City College and developed with the aid of MAST, seeks not just to anticipate future demand, but to help stimulate its emergence by supplying local industry with technicians prepared to assist companies in transitioning to advanced manufacturing technologies.

Recognizing the need to increase the supply of new skilled workers in this and other occupations for the metal and metals-related industries, the U.S. Department of Education launched the Cooperative Demonstration Program (Manufacturing Technologies) as part of the national Skills Standards Act of 1994. The goal of the Department initiative was to foster the development and implementation of national skill standards and a training model for certificate and Associate of Science degree programs. In July 1994, a multi-state consortium of community colleges led by Texas State Technical College received a grant awarded by the Department under the initiative. The Machine Tool Advanced Skills Technology (MAST) consortium, which includes six of the nation's leading Advanced Technology Centers (ATCs), was formed to develop, test and disseminate industry-specific skill standards and model curricula for the U.S. machine tool industry over a two year period. As part of the MAST consortium, San Diego City College in California was tasked with developing and piloting skill standards and model curricula in the technical area of Automated Equipment Technician/CIM.

This occupational specialty area has been identified with a number of different titles. These include: CIM Technician, Shop Floor Control Systems Technician, Flexible Manufacturing Systems Technician, CNC Maintenance Technician, and others. After numerous interviews with practitioners from industry (see Appendix A), and discussions with educators, managers, supervisors, and others involved with machine related occupations and specifically the repair of automated and computer controlled equipment, the MAST Consortium Partners chose to identify this person as an "Automated Equipment Technician/CIM". Our definition of this individual is as follows:

Automated Equipment Technician/CIM - *Operates, programs, maintains, and repairs automated machine tools and automated manufacturing processes.*

Presented in this volume are the course syllabi and all supporting documentation which were used in the pilot program at San Diego City College (CACT) during the 1995-96 school year for the Automated Equipment Technician/CIM Program.

PARTNER OCCUPATIONAL SPECIALITY ASSIGNMENTS

Although each of the six partner college development centers possessed detailed expertise in each of the MAST 15 occupational specialities, a division of work was still very necessary to ensure completion of the project due to the enormity associated with industrial assessment and complete curriculum revision for each of the areas of investigation.

Each Collegiate Partner was responsible for development of a specialization component of the overall model. Information for the future direction of this specialization area was obtained from NIST Manufacturing Centers and/or national consortia, professional societies, and industrial support groups addressing national manufacturing needs. Each Collegiate Partner tested its specialization model utilizing local campus resources and local industry. Information gained from the local experience was utilized to make model corrections. After testing and modification, components were consolidated into a national model. These events occurred during the first year of the Program. During the second year of the Program, the national model was piloted at each of the Collegiate Partner institutions. Experience gained from the individual pilot programs was consolidated into the final national model.

What follows is a profile of the MAST development center which had primary responsibility for the compilation and preparation of the materials for this occupational specialty area. This college also had the responsibility for conducting the pilot program which was used as one of the means of validation for this program.

MAST DEVELOPMENT CENTER, SAN DIEGO, CA
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Manufacturing in the San Diego Region

Manufacturing represents a major sector of the San Diego economy, accounting for almost one out of every four dollars (24%) of San Diego's gross regional product. The county is currently home to approximately 3,500 manufacturers employing roughly 110,000 San Diegans. During the first half of the 1990s, manufacturing in San Diego was hard hit by the downturn in military and defense spending which accompanied the end of the cold war. Many of the region's largest aerospace contractors rapidly downsized or moved their plants out of state, leaving a large supplier base that needed to modernize its manufacturing processes and convert to commercial markets. Rapid recovery of manufacturing in the region has been driven by San Diego's high tech research and development sectors in electronics, telecommunications, software, advanced materials, biotechnology, and medical instrumentation.

San Diego City College and its Center for Applied Competitive Technologies (CACT)

San Diego City College is an urban, minority institution, serving a large population of students from immigrant, disadvantaged, and low income households. In 1990, the College saw an opportunity to modernize its technical programs and improve the employment outlook for many of its students by agreeing to host one of the State of California's eight new regional manufacturing extension centers, the Centers for Applied Competitive Technologies (CACTs). The advanced technology centers were designed to assist local companies to modernize their manufacturing processes and convert from defense to newly emerging, technology-based commercial markets. This strategic partnership between the College and its resident CACT has proven to be highly successful. In developing the programs and lab facilities to serve the needs of regional manufacturing companies, the San Diego CACT and City College have simultaneously modernized the manufacturing and machine technology credit offerings of the College, thereby providing a well-trained, technically competent workforce for industry and enhancing career opportunities for students.

Development Team

- **Project Director:** Joan A. Stepsis, Ph.D., Dean/Director of the CACT-SD, served as programmatic manager and academic coordinator for the MAST project.
- **Subject Matter Expert:** John C. Bollinger, Assoc. Prof. of Machine Technology, had programmatic responsibility for developing skill standards and course/program materials for the Advanced CNC and CAM component of the MAST project. Professor Bollinger also served as the lead instructor for the MAST instructional pilot for his specialty area.
- **Subject Matter Expert:** Douglas R. Welch, Assoc. Prof. of Manufacturing, had programmatic responsibility for developing skill standards and course/program materials for the Automated Equipment Technology (AET) and Machine Tool Integration (CIM) component of the MAST project. Professor Welch also served as lead instructor for the MAST instructional pilot for his specialty area.
- **Skills Validation Coordinator:** Mary K. Benard, MBA, CACT-SD Business/Operations Manager, coordinated the industry skills verification process for MAST with the assistance of Louis A. Spain, Jr., of Spain & Associates, who facilitated industry skills validation sessions with expert worker teams.

THE MAST COMPETENCY PROFILE

Development of Competency Profiles at each of the MAST sites began with visits to representative companies for the purpose of surveying expert workers within the industry and occupational areas under investigation. Each site began the survey process by asking a subject matter expert in the targeted technical area, generally a member of their faculty, to employ a modified version of the generally-accepted DACUM (Developing A Curriculum) method to categorize the major skills needed to work in the selected occupation. As source materials, the college instructors drew on their professional knowledge and experience of current and future industry requirements. The initial skill standards developed by the subject matter experts underwent numerous internal reviews and revisions within each site, assuming final form as a series of structured survey and interview statements designed to elicit a simple yes or no response.

To determine an appropriate survey sample, each site compiled a database of their region's small and medium-sized manufacturers and searched for companies likely to employ workers in the targeted occupational area. The resulting cross-industry samples were sorted further to achieve a balance of technological capability and workforce size; the sample companies within each region were then asked to participate in the project. Willing respondents were scheduled for interviews.

During the company interviews, MAST staff asked expert workers to identify the primary duties and tasks performed by a typical worker and to consider the special skills and knowledge, traits and attitudes, and industry trends that will have an impact on worker training, employability, and performance both now and in the future. The interview results were analyzed to create individual profiles identifying the most common duties and skills required of workers at each company. Copies of individual company competency profiles are provided in Appendix A of this volume. These individual company Competency Profiles served two purposes. First, they showed, in a format that could be easily understood by both industry and educators, a picture of the occupational specialty at a given company at that particular time. Second, these individual company Competency Profiles furnished the company with a document for which they could claim ownership. This, in effect, made them "real" partners in the work of MAST.

Data for all companies were then aggregated to develop a composite Competency Profile of industry skill standards within the selected occupational specialty area of, as shown in the following pages.

These same duties and tasks were then included in both the Texas and National Surveys for further validation (see Volume 1). As a result of the surveys, additional refinements were made to the Competency Profiles. These changes were then incorporated into the individual course syllabi which were used for the pilot program.

The MAST Competency Profile for this occupational specialty area has been included on the following pages.

OCCUPATIONAL SURVEY AND COMPETENCY PROFILE

San Diego City College/Center for Applied Competitive Technologies

San Diego City College is a predominantly minority institution in a city where defense cutbacks and economic recession have shuttered scores of plants and businesses and eliminated tens of thousands of jobs. To continue to meet the needs of its students and ensure their present and future employability, City College has worked closely with industry to design comprehensive Associate of Applied Sciences (AAS) Degree programs in science, math, engineering, and technology, as well as certificate programs in advanced machine tool and manufacturing technologies. These partnerships have helped to leverage public funds and led to the creation of a state-of-the-art applied research facility on the College campus. Key to this effort has been the role of the Center for Applied Competitive Technologies at San Diego City College (CACT-SDCC).

CACT-SDCC was established in 1990 as one of the eight advanced technology centers (ATCs) funded by the State of California to help manufacturers modernize their production capabilities and remain competitive through education, training and technology transfer. Now six years old and a leading institution for applied research, education and training in automated manufacturing and machine technology, CACT-SDCC serves over 3,500 small and mid-sized manufacturers in San Diego and Imperial Counties. The Center is a member of the National Coalition of Advanced Technology Centers (NCATC), an affiliate of the NIST California Manufacturing Technology Center (CMTC), based at El Camino College in Los Angeles, and the sole provider of the State's California Aerospace Supplier Improvement Program (CalSIP) for the San Diego region.

The roles of San Diego City College and CACT-SDCC in the MAST project mirror their reasons for selection to the consortium assembled by Texas State Technical College. City College provides the infrastructure of faculty, students, research facilities, and beta site for the model curriculum, while CACT-SDCC lends its knowledge and expertise as CMTC affiliate and NCATC member and its ongoing relationships with manufacturers.

Automated Equipment Technician/CIM: Survey Methodology

The Automated Equipment Technician/CIM survey methodology was designed to build on the strength of CACT-SDCC's existing relationship to the region's industrial base, as it was assumed that the Center's industry experience and knowledge would ensure the relevance and credibility of the skills survey and eventual curriculum. Given the compressed time frame for conducting the MAST industry survey, CACT-SDCC asked a member of the College faculty, a subject matter expert in automated industrial equipment technologies, to employ a modified version of the generally-accepted DACUM (Developing A Curriculum) process to identify the major types of skills required for employment in the selected occupation. As source materials, the subject matter expert drew on his professional knowledge of industry requirements gained as an active consultant to industry for CACT-SDCC, and his insights and experience as an instructor responsible for redesigning the new College curriculum.

The initial set of skill standards developed by the subject matter expert underwent numerous internal reviews and revisions by a team of CACT-SDCC staff, working with a manufacturing consultant with twenty years of industry experience. Upon assuming its final form as a series of structured statements designed to elicit a simple yes or no response, the resulting survey was sent to an industry sample for review.

To determine an appropriate sample survey population, CACT-SDCC searched its database of the region's small and medium-sized manufacturers for companies likely to employ Automated Equipment Technician/CIMs. The resulting database of companies included both smaller tool and die shops with minimal technology and large aerospace manufacturers with a substantial investment in advanced technology; this sample was sorted further to achieve a balance of technological capability and workforce size. A total of 10 companies were sent the survey and asked to serve as interviewees.

Six companies ultimately agreed to participate in the entire survey process. About half of the companies were current or previous CACT-SDCC clients, ranging in size from as few as three to over 5,000 employees. The companies included: Davis Technologies, a small machine shop; Southwest Fabricators, a job shop; Eaton Leonard, a subsidiary of a large manufacturer; NASSCO, a large shipbuilder; and Rohr and Teledyne Ryan, both large aerospace manufacturers. The level of technological sophistication in the participating companies ranged from 30 year-old numerical control tape machines without a local area network to 486-based machines capable of receiving machine code from a central hub and deleting out-dated code from the same hubs remotely.

The CACT-SDCC Site Coordinator and the manufacturing consultant sent the full survey to all six companies and followed up with a one and a half hour structured interview at each site, generally with the director of manufacturing or CEO. Survey results were entered into the CACT-SDCC computer database and aggregated into individualized Competency Profiles for the surveyed companies. The Competency Profile is a matrix consisting of rows of Duties (e.g., "Program CNC machines and EDM") and columns of Tasks (e.g., "Describe and interpret CNC coding systems"). The individual Profiles were returned to the companies for further review and verification; final company Competency Profiles are described below and provided in Appendix 1.

Competency Profile Results

Reflecting the multiple functions encompassed by the job description, companies tended to vary in their identification of duties and tasks required for Automated Equipment Technician/CIM. They felt the ideal candidate would be a systems troubleshooter with a balanced knowledge of computers, electronics, electrical, and mechanical systems. The knowledge base of each skill is less extensive than in the past, but it must be sufficient to determine a problem caused by any or all of the four aspects of the industrial system. In general, the technician should have a knowledge of computer systems, control systems, manufacturing processes and techniques, and the problem-solving skills needed to isolate malfunctions in an industrial process.

The companies all identified the same list of "Current Trends/Concerns": Statistical Process Control, Laser Machining, Robotics, Environmental Concerns, Composites, Fiber Optic Controls, Advanced Computer Applications, Automated Material Handling Equipment, and CIM. Eaton Leonard added ISO 9000 to their list. With one exception, companies also identified the same required "Tools and Equipment" Southwest Fabricators did not require the use of a coordinate measuring machine; pneumatic, SCARA or articulated robots, or robot programming software; heat treatment equipment; hand-held PLC programming terminals; or measuring instruments for mechanical parts.

Industry responses to open-ended questions tended to emphasize their particular areas of interest and generated valuable data that have been incorporated into the draft curriculum outline. It was clear from the level of interest shown by interviewees that the survey process had raised awareness of City College/CACT-SDCC capabilities; they were obviously surprised to discover a local source of advanced manufacturing training, based on industry standards, within a community college program. It is clear that the College's new Automated Equipment Technician/CIM program has the potential to help generate regional demand for its own product, as companies learn more about the program and begin to modify their production capability to incorporate available sources of labor market expertise and technology. The survey also appeared to cause the companies to examine their own technology needs and practices and to think systematically about the skills they would like to see in employees.

Occupational Requirements for Automated Equipment Technician/CIM

The review of the MAST skill standards by local manufacturers validated the basic knowledge and skill competencies identified as occupational requirements for Automated Equipment Technician/CIM by the subject matter experts. This broad set of technical knowledge and competencies is known as"mechatronics", a new field combining study of the principles of mechanical systems and electronics with the systems analysis required to identify deviation and determine a solution. In general, manufacturers desire entry-level technicians with the theoretical knowledge and hands-on ability to operate, program, and repair the new automated systems and manufacturing processes, including flexible manufacturing systems, CNCs, robots, and controllers, as well as the broader perspective to know when to call in the repair man or supplier for maintenance or process improvement.

SCANS

The MAST skill standards development process incorporated a modified version of the five work-related competencies and three foundation skills identified by the Secretary's Commission on Achieving Necessary Skills (SCANS) as being essential to every job. Industry survey respondents were asked to review two SCANS skill sets -- i.e., Skills and Knowledge, and Traits and Attitudes -- in the context of the proposed occupational skill standards. The industry-verified SCANS shills will be incorporated into the Automated Equipment Technician/CIM instructional curricula through selected courses.

SKILLS AND KNOWLEDGE

Communication Skills
Use Measurement Tools
Use Inspection Devices
Mathematical Skills
Reading/Writing Skills
Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
Mechanical Aptitude
Ability to Comprehend Written/Verbal Instructions
Basic Knowledge of Fasteners
Ability to Work as Part of a Team
Converse in the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Knowledge of Company Quality Assurance Activities
Practice Quality-Consciousness in Performance of the Job
Knowledge of Computers
CAD/CAM Experience
Manual Machining Experience

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CACT
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San Diego City College

TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Eager to Learn
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Customer Relations
Personal Ethics

TOOLS AND EQUIPMENT FOR AET

Hand Tools

Hand tools appropriate to the construction, repair, and maintenance of electrical equipment such as electrical control systems and electrical motors
Hand tools appropriate to the construction, repair, and maintenance of electronic equipment such as computer controlled automated machinery
Hand tools appropriate to the construction, repair, and maintenance of hydraulic or pneumatic systems and components

Equipment

Power supplies
Electronics test units
Electrical test units
Hydraulic test units
Pneumatic test units
Electrical components
Wire and cable, connectors
Computers 386, 486
Digital electronic components
Robot Programming software
PLC Programming software
Robots, SCARA and Articulated
Pneumatic manipulators
Pneumatic fittings/components
Programmable Logic Controllers
Alignment/Calibration tools
Tool storage equipment
Vises
Electrical motors
Stepper motors
Electronic motor controls
Electronic components
Electronic enclosures
Electrical enclosures
Analog multimeters
Digital multimeters
Oscilloscopes
FMS Programming software
CNC machines
Robot, pneumatic (bang-bang)
Hydraulic/pneumatic components
Hydraulic fittings/components
Heat treatment equipment
Personal safety equipment
Workbenches
Weld test equipment
Coordinate Measurement Machine
Motion control servo systems test units
Wire termination devices, terminal lugs, etc.
Measuring instruments for mechanical parts - accuracy to .0001 inch
Hand held PLC programming terminals
Temperature, pressure, force, rotational velocity, and chemical measuring instruments
Welding equipment (SMAW, GMAW, FCAW)

CURRENT TRENDS\CONCERNS

Statistical Process Control
Laser Machining
Environmental concerns
Composites
Robotics
Fiber Optic Controls
Automated Material Handling Equipment
Computer Integrated Manufacturing
Advanced Computer Appplications

COMPETENCY PROFILE

Automated Equipment Technician/CIM

Prepared By
M.A.S.T.
Machine Tool Advanced Skills
Technology Program
and
Consortium Partners
(V.199J40008)

*M*achine Tool *A*dvanced *S*kills *T*echnology Program

MAST

AUTOMATED EQUIPMENT TECHNICIAN/CIM .... operates, programs, maintains, and repairs automated machine tools and automated manufacturing processes.

	Duties	Tasks												
A	Apply science to solve industrial problems	A-1 Apply scientific notation and engineering notation to solve technical problems	A-2 Apply algebraic formulas to solve technical problems	A-3 Use variables in algebraic formulas to predict behavior of industrial systems	A-4 Manipulate variables in algebraic formulas to analyze industrial systems	A-5 Use physics, algebra, and trigonometry to analyze simple vectored forces	A-6 Use mechanical physics to analyze mechanical industrial systems	A-7 Measure, calculate, and convert quantities in English and Metric (SI,mks) systems	A-8 Use math and mechanical physics to analyze problems found in hydraulic, and pneumatic systems	A-9 Use math and thermodynamics to analyze problems found in industrial heat treating systems	A-10 Use math, the physics of electromagnetism and optics to analyze industrial systems	A-11 Use math, physics, and chemical measurements to determine physical quantities	A-12 Use math and chemical measurements to determine compounds, solutions, or mixtures	A-13 Use proper lab procedures to test chemicals used in industrial processes
		A-14 Use chemical formulas to predict and analyze reactions in industrial processes	A-15 Use proper laboratory methods to test the properties of elements and compounds	A-16 Apply the knowledge of electrochemical effects to analyze chemical industrial processes	A-17 Apply properties of water to analyze industrial water treatment processes									
B	Use drawings to analyze and repair systems	B-1 Use symbols, organization, and engineering values on mechanical drawings	B-2 Use symbols, organization, and engineering values on electrical drawings	B-3 Use symbols, organization and engineering values on electronic drawings	B-4 Use symbols, organization and engineering values on fluid power drawings	B-5 Use symbols, organization and engineering values on digital drawings								
C	Use calibrated measuring instruments to test/calibrate components	C-1 Apply machine tool metrology and measurement instruments to align machine tools	C-2 Apply electrical measurement knowledge and instruments to test/calibrate electrical circuits	C-3 Apply electronic measurement knowledge and instruments to test/calibrate electronic circuits	C-4 Apply fluid power measurement and instruments to test/calibrate hydraulic and pneumatic systems	C-5 Apply digital electronic measurement knowledge and instruments to test/calibrate digital electronic circuits								
D	Explain test results to team leaders, engineers, customers, and other technicians	D-1 Use written English language, write complete proper sentences	D-2 Use written English language to effectively communicate results of technical tests and instructions	D-3 Use a word processor; obtain information from various sources and write effective reports	D-4 Use spoken English language to communicate feelings, thoughts, ideas, and technical information									
E	Resolve system failures with critical thinking, troubleshooting, theory and Metrology	E-1 Identify nature/purpose of a system, subsystem, module, or component in a complex manufacturing machine/process	E-2 Apply theory to predict behavior of a complex manufacturing machine or process	E-3 Measure complex manufacturing machine/process to determine if meeting theoretical expectations	E-4 Analyze results to determine if system, subsystem, module, or component is meeting manufacturers specifications	E-5 Apply critical thinking to determine if system is malfunctioning or if process must be reapplied	E-6 Validate the process and apply corrective action	E-7 If corrective action does not result in repair of system, reapply the process						
F	Use techniques to isolate malfunction of electronic systems	F-1 Calculate, predict and measure the response of quantities in DC circuits	F-2 Calculate, predict, and measure the response of quantities in AC circuits	F-3 Calculate, predict and measure impedance and phase angle in AC circuits	F-4 Calculate, predict, and measure quantities in polyphase AC circuits	F-5 Properly set-up, calibrate, and use meters and oscilloscopes	F-6 Use components such as resistors, inductors, and capacitors; construct circuits and test components	F-7 Use meters/oscilloscopes to measure phase shift or angle in series resistive-capacitive/resistive-inductive AC circuits	F-8 Apply electromagnetism theory to determine operational characteristics of relays, solenoids, transformers, and electrical motors for DC and AC circuits		F-9 Use meters and oscilloscopes to test magnetically coupled devices	F-10 Apply principles of DC electrical motors to identify types of DC motors	F-11 Apply principles of AC electrical motors to identify AC motors	F-12 Use rules of semiconductor devices and meters or oscilloscopes to test diodes
		F-13 Use meters or oscilloscopes to test bipolar transistors and power MOSFETs	F-14 Use meters/oscilloscopes to test power control semi-conductors and their triggering devices	F-15 Use meters/oscilloscopes to test power supply circuits, including rectifiers/filtering circuits for 1 and 3 phase DC power supplies	F-16 Use schematics and meters or oscilloscopes to identify, replace and/or troubleshoot and repair, series, shunt, and switching semiconductor, DC power supply, regulator circuits		F-17 Use schematics and meters or oscilloscopes to differentiate between various types of DC motor control circuits and replace and/or troubleshoot and repair these motor controls		F-18 Use schematic diagrams and meters or oscilloscopes to identify advanced motor controls that contain newer, types of semiconductor devices, to troubleshoot and repair these motor controls		F-19 Apply semiconductor theory and amplifier concepts to troubleshoot and replace or repair the module containing the circuit		F-20 Use schematic diagrams and meters or oscilloscopes to test electrical devices	F-21 Use schematic diagrams and meters or oscilloscopes to test sensors
G	Measure/isolate malfunctions of mechanical/fluid power systems	G-1 Know purpose and use of major systems that comprise a hydraulic/pneumatic system to troubleshoot components or systems	G-2 Apply purpose and use of valves in a hydraulic or pneumatic system to troubleshoot components or systems	G-3 Use formulas and mathematics to calculate quantities in hydraulic and pneumatic systems	G-4 Use fluid power measuring instruments to test the operating condition of the fluid power system	G-5 Test the condition and behavior of fluids in a fluid power system	G-6 Use the knowledge of flow; measure flow in a fluid power system	G-7 Calculate, measure, and troubleshoot hydraulic and pneumatic accumulators	G-8 Apply hydraulic, pneumatic, and high vacuum systems knowledge to test, troubleshoot, and repair special components/devices	G-9 Identify, assemble, measure and apply knowledge of operating characteristics of selected, specialized fluid power circuits	G-10 Identify, assemble, measure, and apply knowledge of operating characteristics of electrically operated, specialized fluid power circuits	G-11 Understand and use proper instruments and troubleshooting methods for fluid power circuits	G-12 Use laws of simple machines and physics to identify and troubleshoot complex machines	G-13 Use laws of simple machines and physics to troubleshoot gearing systems
H	Apply computer science to computer controlled industrial equipment	H-1 Convert mathematical quantities in digital numbering systems	H-2 Perform mathematical operations in digital numbering systems	H-3 Read digital symbology and relate it to control of digitally operated equipment	H-4 Express a complex logic problem in Boolean, and convert it into symbolic logic	H-5 Solve digital logic circuits and ladder diagrams in electrical and programmable logic control circuits	H-6 Express a complex logic problem in Boolean and convert it into ladder logic	H-7 Use various programming devices and Boolean algebra to program computer controlled industrial equipment	H-8 Use various programming concepts to program industrial equipment					

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	Duties	Tasks												
	Page 2													
I	Correct malfunctions in PLC controlled industrial equipment	I-1 Use a data entry device to setup and configure a PLC/PIC to control digital and analog input/output points	I-2 Set up/configure PIC/PLC as part of control system of CNC machine/Robot to control digital and analog I/O points	I-3 Use equipment manuals, manufacturers specifications, and data entry/monitoring devices to connect and test digital and analog I/O points of a PLC or PIC		I-4 Use equipment manuals, manufacturers specifications, and data entry/monitoring devices to test and troubleshoot setup of a PLC or PIC system and solve control problems								
J	Resolve malfunctions found in computer systems controlling manufacturing processes	J-1 Operate different classes of personal computers	J-2 Maintain hardware/software of a personal computer	J-3 Configure and troubleshoot communications interfaces	J-4 Test the hardware of a personal computer									
K	Assemble/disassemble mechanical, electrical, electronic, and computer systems	K-1 Safely assemble or disassemble mechanical systems such as gearing systems, shafts, couplings, pulleys, belts	K-2 Adjust mechanical systems such as gearing systems, shafts, couplings, pulleys, and belts	K-3 Safely assemble or disassemble subsystems or components of fluid power systems	K-4 Adjust subsystems or components of fluid power systems	K-5 Safely assemble or disassemble electrical systems or components	K-6 Adjust electrical systems or components	K-7 Safely assemble or disassemble electronic systems or components	K-8 Safely adjust electronic systems or components such as closed loop motor control modules, servo systems, and proportional band integral derivative controls		K-9 Safely assemble or disassemble digital systems or components such as PLCs, CNCs or computers			
L	Use teamwork to accomplish job tasks and contribute to success of the company	L-1 Participate in team projects and contribute to success of the team and the project	L-2 Participate as a member of manufacturing enterprise and contribute to success of the company	L-3 Apply cooperation and self management techniques to work with members the of team and accomplish tasks										

THE MAST TECHNICAL WORKPLACE COMPETENCY OUTLINE

The Competency Profiles derived from the industry survey process were returned to industry and faculty members at each MAST partner college for review. Reviewers were asked to identify specific sub-tasks within each block of Duties and Tasks in the Profile; MAST staff at each college broke the sub-tasks down further into the detailed steps required to actually perform the duties and tasks of the manufacturing process. It is these detailed skill standards that were then incorporated into development of the curriculum and piloted as a training program by each of the MAST colleges. All results for the specific occupational specialty area have been organized as an outline of the duties, tasks, and sub-tasks required to demonstrate technical competency in the workplace, as shown in the following pages.

As a result of the Texas and the National Surveys, additional refinements were made to the Competency Outlines. These changes were then incorporated into the individual course syllabi.

The MAST Technical Workplace Competency Outline for this occupational specialty area has been included on the following pages.

AUTOMATED EQUIPMENT TECHNICIAN/CIM
TECHNICAL WORKPLACE COMPETENCIES

AUTOMATED EQUIPMENT TECHNICIAN/CIM...*operates, programs, maintains, and repairs automated machine tools and automated manufacturing processes.*

A. APPLY SCIENCE TO SOLVE INDUSTRIAL PROBLEMS

1. Apply Scientific Notation and Engineering Notation to Solve Technical Problems
2. Apply Algebraic Formulas to Solve Technical Problems
3. Use Variables in Algebraic Formulas to Predict Behavior of Industrial Systems
4. Manipulate Variables in Algebraic Formulas to Analyze Industrial Systems
5. Use Physics, Algebra, and Trigonometry to Analyze Simple Vectored Forces
6. Use Mechanical Physics to Analyze Mechanical Industrial Systems
7. Measure, Calculate, and Convert Quantities in English and Metric (SI, mks) Systems
8. Use Math and Mechanical Physics to Analyze Problems Found in Hydraulic and Pneumatic Systems
9. Use Math and Thermodynamics to Analyze Problems Found in Industrial Heat Treating Systems
10. Use Math, the Physics of Electromagnetism and Optics to Analyze Industrial Systems
11. Use Math, Physics, and Chemical Measurements to Determine Physical Quantities
12. Use Math and Chemical Measurements to Determine Compounds, Solutions, or Mixtures
13. Use Proper Lab Procedures to Test Chemicals Used in Industrial Processes
14. Use Chemical Formulas to Predict and Analyze Reactions in Industrial Processes
15. Use Proper Laboratory Methods to Test the Properties of Elements and Compounds
16. Apply the Knowledge of Electrochemical Effects to Analyze Chemical Industrial Processes
17. Apply Properties of Water to Analyze Industrial Water Treatment Processes

B. USE DRAWINGS TO ANALYZE AND REPAIR SYSTEMS

1. Use Symbols, Organization, and Engineering Values on Mechanical Drawings
2. Use Symbols, Organization, and Engineering Values on Electrical Drawings
3. Use Symbols, Organization and Engineering Values on Electronic Drawings
4. Use Symbols, Organization and Engineering Values on Fluid Power Drawings
5. Use Symbols, Organization and Engineering Values on Digital Drawings

C. USE CALIBRATED MEASURING INSTRUMENTS TO TEST/CALIBRATE COMPONENTS

1. Apply Machine Tool Metrology and Measurement Instruments to Align Machine Tools
2. Apply Electrical Measurement Knowledge and Instruments to Test/Calibrate Electrical Circuits
3. Apply Electronic Measurement Knowledge and Instruments to Test/Calibrate Electronic Circuits

4. Apply Fluid Power Measurement and Instruments to Test/Calibrate Hydraulic and Pneumatic Systems
5. Apply Digital Electronic Measurement Knowledge and Instruments to Test/Calibrate Digital Electronic Circuits

D. EXPLAIN TEST RESULTS TO TEAM LEADERS, ENGINEERS, CUSTOMERS, AND OTHER TECHNICIANS

1. Use Written English Language; Write Complete Proper Sentences
2. Use Written English Language to Effectively Communicate Results of Technical Tests and Instructions
3. Use a Word Processor; Obtain Information from Various Sources and Write Effective Reports
4. Use Spoken English Language to Communicate Feelings, Thoughts, Ideas, and Technical Information

E. RESOLVE SYSTEM FAILURES WITH CRITICAL THINKING, TROUBLESHOOTING, THEORY AND METROLOGY

1. Identify Nature/Purpose of a System, Subsystem, Module, or Component in a Complex Manufacturing Machine/Process
2. Apply Theory to Predict Behavior of a Complex Manufacturing Machine or Process
3. Measure Complex Manufacturing Machine/Process to Determine If Meeting Theoretical Expectations
4. Analyze Results to Determine If System, Subsystem, Module, or Component Is Meeting Manufacturer's Specifications
5. Apply Critical Thinking to Determine If System Is Malfunctioning or If Process must Be Reapplied
6. Validate the Process and Apply Corrective Action
7. If Corrective Action Does Not Result in Repair of System, Reapply the Process

F. USE TECHNIQUES TO ISOLATE MALFUNCTION OF ELECTRONIC SYSTEMS

1. Calculate, Predict, and Measure the Response of Quantities in DC Circuits
2. Calculate, Predict, and Measure the Response of Quantities in AC Circuits
3. Calculate, Predict, and Measure Impedance and Phase Angle in AC Circuits
4. Calculate, Predict, and Measure Quantities in Polyphase AC Circuits
5. Properly Set-up, Calibrate, and Use Meters and Oscilloscopes
6. Use Components Such as Resistors, Inductors, and Capacitors; Construct Circuits and Test Components
7. Use Meters/Oscilloscopes to Measure Phase Shift or Angle in Series Resistive-Capacitive/Resistive-Inductive AC Circuits
8. Apply Electromagnetism Theory to Determine Operational Characteristics of Relays, Solenoids, Transformers, and Electrical Motors for DC and AC Circuits
9. Use Meters and Oscilloscopes to Test Magnetically Coupled Devices
10. Apply Principles of DC Electrical Motors to Identify Types of DC Motors
11. Apply Principles of AC Electrical Motors to Identify AC Motors
12. Use Rules of Semiconductor Devices and Meters or Oscilloscopes to Test Diodes
13. Use Meters or Oscilloscopes to Test Bipolar Transistors and Power MOSFETs

14. Use Meters/Oscilloscopes to Test Power Control Semi-conductors and Their Triggering Devices
15. Use Meters/Oscilloscopes to Test Power Supply Circuits, Including Rectifiers/Filtering Circuits for 1 and 3 Phase DC Power Supplies
16. Use Schematics and Meters or Oscilloscopes to Identify, Replace and/or Troubleshoot and Repair, Series, Shunt, and Switching Semiconductor, DC Power Supply, Regulator Circuits
17. Use Schematics and Meters or Oscilloscopes to Differentiate Between Various Types of DC Motor Control Circuits and Replace and/or Troubleshoot and Repair These Motor Controls
18. Use Schematic Diagrams and Meters or Oscilloscopes to Identify Advanced Motor Controls That Contain Newer Types of Semiconductor Devices, to Troubleshoot and Repair These Motor Controls
19. Apply Semiconductor Theory and Amplifier Concepts to Troubleshoot and Replace or Repair the Module Containing the Circuit
20. Use Schematic Diagrams and Meters or Oscilloscopes to Test Electrical Devices
21. Use Schematic Diagrams and Meters or Oscilloscopes to Test Sensors

G. MEASURE/ISOLATE MALFUNCTIONS OF MECHANICAL /FLUID POWER SYSTEMS

1. Know the Purpose and Use of Major Systems That Comprise a Hydraulic/Pneumatic System to Troubleshoot Components or Systems
2. Apply Purpose and Use of Valves in a Hydraulic or Pneumatic System to Troubleshoot Components or Systems
3. Use Formulas and Mathematics to Calculate Quantities in Hydraulic and Pneumatic Systems
4. Use Fluid Power Measuring Instruments to Test the Operating Condition of the Fluid Power System
5. Test the Condition and Behavior of Fluids in a Fluid Power System
6. Use the Knowledge of Flow; Measure Flow in a Fluid Power System
7. Calculate, Measure, and Troubleshoot Hydraulic and Pneumatic Accumulators
8. Apply Hydraulic, Pneumatic, and High Vacuum Systems Knowledge to Test, Troubleshoot, and Repair Special Components/Devices
9. Identify, Assemble, Measure, and Apply Knowledge of Operating Characteristics of Selected, Specialized Fluid Power Circuits
10. Identify, Assemble, Measure, and Apply Knowledge of Operating Characteristics of Electrically Operated, Specialized Fluid Power Circuits
11. Understand and Use Proper Instruments and Troubleshooting Methods for Fluid Power Circuits
12. Use Laws of Simple Machines and Physics to Identify and Troubleshoot Complex Machines
13. Use Laws of Simple Machines and Physics to Troubleshoot Gearing Systems

H. APPLY COMPUTER SCIENCE TO COMPUTER CONTROLLED INDUSTRIAL EQUIPMENT

1. Convert Mathematical Quantities in Digital Numbering Systems
2. Perform Mathematical Operations in Digital Numbering Systems
3. Read Digital Symbology and Relate it to Control of Digitally Operated Equipment

4. Express a Complex Logic Problem in Boolean, and Convert it into Symbolic Logic
5. Solve Digital Logic Circuits and Ladder Diagrams in Electrical and Programmable Logic Control Circuits
6. Express a Complex Logic Problem in Boolean and Convert it into Ladder Logic
7. Use Various Programming Devices and Boolean Algebra to Program Computer Controlled Industrial Equipment
8. Use Various Programming Concepts to Program Industrial Equipment

I. CORRECT MALFUNCTIONS IN PLC CONTROLLED INDUSTRIAL EQUIPMENT

1. Use a Data Entry Device to Set up and Configure a PLC/PIC to Control Digital and Analog Input/Output Points
2. Set Up/Configure PIC/PLC as Part of the Control System of CNC Machine/Robot to Control Digital and Analog I/O Points
3. Use Equipment Manuals, Manufacturer's Specifications, and Data Entry/Monitoring Devices to Connect and Test Digital and Analog I/O Points on a PLC or PIC
4. Use Equipment Manuals, Manufacturer's Specifications, and Data Entry/Monitoring Devices to Test and Troubleshoot Set up of a PLC or PIC System and Solve Control Problems

J. RESOLVE MALFUNCTIONS FOUND IN COMPUTER SYSTEMS CONTROLLING MANUFACTURING PROCESSES

1. Operate Different Classes of Personal Computers
2. Maintain Hardware/Software of a Personal Computer
3. Configure and Troubleshoot Communications Interfaces
4. Test the Hardware of a Personal Computer

K. ASSEMBLE/DISASSEMBLE MECHANICAL, ELECTRICAL, ELECTRONIC, AND COMPUTER SYSTEMS

1. Safely Assemble or Disassemble Mechanical Systems Such as Gearing Systems, Shafts, Couplings, Pulleys, Belts
2. Adjust Mechanical Systems Such as Gearing Systems, Shafts, Couplings, Pulleys, and Belts
3. Safely Assemble or Disassemble Subsystems or Components of Fluid Power Systems
4. Adjust Subsystems or Components of Fluid Power Systems
5. Safely Assemble or Disassemble Electrical Systems or Components
6. Adjust Electrical Systems or Components
7. Safely Assemble or Disassemble Electronic Systems or Components
8. Safely Adjust Electronic Systems or Components Such as Closed Loop Motor Control Modules, Servo Systems, and Proportional Band Integral Derivative Controls
9. Safely Assemble or Disassemble Digital Systems or Components Such as PLCs, CNCs or Computers

L. USE TEAMWORK TO ACCOMPLISH JOB TASKS AND CONTRIBUTE TO SUCCESS OF THE COMPANY

1. Participate in Team Projects and Contribute to Success of the Team and the Project
2. Participate as a Member of Manufacturing Enterprise and Contribute to Success of the Company
3. Apply Cooperation and Self Management Techniques to Work with Members of the Team and Accomplish Tasks

THE MAST PILOT PROGRAM CURRICULUM AND COURSE DESCRIPTIONS

After completing the Competency Profile and Technical Workplace Competency Outline for each occupational specialty area, each MAST partner reviewed their existing curricula against the industry-verified skill standards in order to identify a suitable foundation for new pilot training programs. Because each college had to comply with the requirements of its respective college system and appropriate state agency, the resulting pilot curricula for occupational specialty areas tended to vary in format and academic requirements (e.g., some programs were based on the semester system, others on the quarter system). Despite differences in the curricula developed at the partner colleges, each of the pilot programs was designed to achieve the following two goals mandated in the MAST grant proposal:

- Pilot Program: "Conduct a one year pilot program with 25 or more selected applicants at each college or advanced technology center to evaluate laboratory content and effectiveness, as measured by demonstrated competencies and indicators of each program area."

- Student Assessment: "Identify global skills competencies of program applicants both at point of entrance and point of exit for entry level and already-employed technicians."

(Note: All occupational specialty areas were not pilot tested at all Development Centers; however, all partner colleges conducted one or more pilot programs.)

Included on the following pages is the curriculum listing for the pilot program which was used to validate course syllabi for this occupational specialty area. This curriculum listing included course names and numbers from the college which conducted the pilot program. The curriculum also shows the number of hours assigned to each of the courses (lecture, lab and credit hours). Also included is a description of each of the courses. Also included in this section is a recommended list of tools, equipment and supplies which should be furnished by the school. This items on this list will be needed in addition to the tool list found in each of the course syllabi.

MANUFACTURING TECHNOLOGY
AUTOMATED EQUIPMENT TECHNOLOGY (CIM)
CURRICULUM
1995-1996

		LEC	LAB	CR
MAFG 100	Manufacturing Metrics and Calculations	2	3	3
MAFG 101	Teamwork Skills	0	3	1
MAFG 102	Print Reading and Symbology	3	0	3
MAFG 106	Manufacturing Processes	3	3	4
MAFG 111	Industrial Programming Theory	2	3	3
MAFG 200	Industrial Electronics/Electricity	2	6	4
MAFG 205	Motion Control/Servo Systems	2	6	4
MAFG 210	Fluid Power Technology	2	3	3
MAFG 215	Programmable Logic Controllers	2	3	3
MAFG 220	Industrial Machine Technology	2	3	3
MAFG 225	Flexible Manufacturing Systems/Robotics	2	6	4
	Program Totals	22	39	35

MANUFACTURING TECHNOLOGY
AUTOMATED EQUIPMENT TECHNOLOGY (CIM) OPTION
COURSE DESCRIPTIONS 1995-1996

MAFG 100	Manufacturing Metrics and Calculations (2-3-3) Basic application of mathematical concepts required for effective performance as an automation technician or machine technologist in the machine tool industry. Problem examples will be taken from machines and equipment typically found in the modern industrial manufacturing facility. Associate Degree credit. Prerequisites are eligibility for Math 54, Elementary Algebra, and English 56, College Reading Study Skills.
MAFG 101	Teamwork Skills (0-3-1) Basic application of team problem-solving concepts and techniques required for effective performance as a team member in the business environment. Prerequisite is eligibility for English 56, College Reading Study Skills.
MAFG 102	Print Reading and Symbology (3-0-3) Study of the types of symbols and engineering notations used for mechanical, electrical, hydraulic, and pneumatic drawings. Representative drawings will be used to demonstrate concepts and practice in interpreting the symbols and notations. Students will view and handle typical parts represented by the symbols. Associate Degree credit. Prerequisite is satisfactory completion of MAFG 100, Manufacturing Metrics and Calculations, concurrent enrollment, or equivalent.
MAFG 106	Manufacturing Processes (3-3-4) A survey of physical and chemical processes used to manufacture products. Designed for students who will pursue a career in automated manufacturing, the course will require students to test automated manufacturing processes. The course will also encourage students to pursue further training in physics and chemistry by exploring the principles underlying technologies used to manufacture products found in industry; these technologies will include machine technology, vacuum technology, heat treatment, hydraulic and pneumatic technology, and electro-chemical manufacturing processes. Students will use formulas and New Metric (S.I.) (mks) system of measurement to solve problems of industrial processes. Associate Degree credit. Prerequisite is satisfactory completion of MAFG 100, Manufacturing Metrics and Calculations, or concurrent enrollment, or equivalent.
MAFG 111	Industrial Programming Theory (2-3-3) Basic digital mathematical concepts required for effective performance as an automation technician or machine technologist in the computerized machine tool industry. Example will include computers or microprocessors found in the typical modern industrial manufacturing facility, including industrial computers, programmable logic controllers, and microprocessor-based control systems. Associate Degree Credit. Prerequisite is satisfactory completion of MAFG 100, Manufacturing Metrics and Calculations, concurrent enrollment, or equivalent.

MAFG 200	Industrial Electronics/Electricity (2-6-4) Introduces the principles of operation of common electronics/electrical components through the use of hands-on experiments and classroom lectures. Also include theory of operation of different components such as switches, relays, transformers, motors, sensors, and diodes. Associate Degree credit. Prerequisites are satisfactory completion of, or concurrent enrollment in MAFG 100, Manufacturing Metrics and Calculations, MAFG 102, Print Reading and Symbology, or equivalent.
MAFG 205	Motion Control/Servo Systems (2-6-4) Study of the types of control circuits used to control industrial equipment, including motor, process, and hydraulic controls, as well as feedback systems used in control systems and their theory of operation. Emphasis of closed-loop servo systems and their theory of operation. Students will gain hands-on experience with control systems through lab exercises. Associate Degree credit. Prerequisite is satisfactory completion of MAFG 200, Industrial Electronics/Electricity, or equivalent.
MAFG 210	Fluid Power Technology (2-3-3) Basic principles of hydraulics and pneumatics through hands-on experiments and lecture. Explores various hydraulic and pneumatic systems, circuits, components, and applications. Associate Degree credit. Prerequisites are satisfactory completion of MAFG 102, Print Reading and Symbology, and MAFG 106, Manufacturing Processes, or equivalent.
MAFG 215	Programmable Logic Controllers (2-3-3) Study of concepts associated with the operation, construction, configuring, and programming of programmable logic controllers (PLC). Students will experiment with digital circuits to understand digital logic concepts, and hands-on lab exercises in constructing, operating, configuring, and programming PLCs. Associate Degree credit. Prerequisites are satisfactory completion of MAFG 109, Industrial Programming Theory, and MAFG 200, Industrial Electronics/Electricity, or equivalent.
MAFG 220	Industrial Machine Technology (2-3-3) A survey course designed to provide students with an overview of typical machine shop operations and an introduction to welding technology. Associate Degree credit. Prerequisites are satisfactory completion of MAFG 100, Manufacturing Metrics and Calculations, and MAFG 102, Print Reading and Symbology, or equivalent.
MAFG 225	Flexible Manufacturing Systems/Robotics (2-6-4) Design, installation, operation, and maintenance of a Flexible Manufacturing System (FMS). Includes the role, theory, and programming of robots and work centers in FMS. Lab exercises will cover the assembly, configuring, troubleshooting, and repair of various automated equipment and robots during construction of a flexible manufacturing cell. Associate Degree credit. Prerequisites are satisfactory completion of MAFG 205, Motion Control/Servo Systems, MAFG 210, Fluid Power Technology, MAFG 215, Programmable Logic Controllers, or equivalent.

THE MAST TECHNICAL WORKPLACE COMPETENCY/COURSE CROSSWALK

Upon development of appropriate curricula for the pilot programs, each MAST college began to develop individual course outlines for its assigned specialty area. The skill standards identified in the Competency Profile were cross walked against the technical competencies of the courses in the pilot curriculum. The resulting matrix provided a valuable tool for assessing whether current course content was sufficient or needed to be modified to ensure mastery of entry level technical competencies. Exit proficiency levels for each of the technical competencies were further validated through industry wide surveys both in Texas and across the nation.

The Technical Workplace Competency/Course Crosswalk in the following pages presents the match between industry-identified duties and tasks and the pilot curriculum for . Course titles are shown in columns, duties and tasks in rows. The Exit Level Proficiency Scale, an ascending scale with 5 the highest level of proficiency, includes marked boxes indicating whether the task is covered by the instructor during the course; the numbers 1-5 indicate the degree of attention given to the task and the corresponding proficiency expected on the part of the student. The crosswalk is intended to serve as an aide to other instructional designers and faculty in community college programs across the nation.

Included on the following pages is the Technical Workplace Competency/Course Crosswalk for the pilot program curriculum. This crosswalk validates the fact that the duties and tasks which were identified by industry as being necessary for entry level employees have been incorporated into the development of the course syllabi.

Page 1

Technical Workplace Competencies/Course

CROSSWALK

TECHNICAL COMPETENCY
AUTOMATED EQUIPMENT TECHNICIAN (CIM)

	Technical Skills	Manufacturing Calculations	Blueprint Symbology	Manufacturing Processes	Industrial Programming	Industrial Electricity	Motion Control/Servo	Fluid Power Technology	Programmable Logic Control	Machine Technology	Flexible Manufacturing				EXIT PROFICIENCY LEVEL
A. APPLY SCIENCE TO SOLVE INDUSTRIAL PROBLEMS															
A-1 Apply Scientific Notation and Engineering Notation to Solve Technical Problems		X	X	X	X	X	X	X	X	X	X				4
A-2 Apply Algebraic Formulas to Solve Technical Problems		X	X	X	X	X	X	X	X	X	X				5
A-3 Use Variables in Algebraic Formulas to Predict Behavior of Industrial Systems		X		X	X	X	X	X	X	X	X				4
A-4 Manipulate Variables in Algebraic Formulas to Analyze Industrial Systems		X		X	X	X	X	X		X	X				4
A-5 Use Physics, Algebra, and Trigonometry to Analyze Simple Vectored Forces		X		X			X	X		X	X				4
A-6 Use Mechanical Physics to Analyze Mechanical Industrial Systems		X		X		X	X	X			X				4
A-7 Measure, Calculate, and Convert Quantities in English and Metric (SI, mks) Systems		X		X	X	X	X	X	X		X				5
A-8 Use Math and Mechanical Physics to Analyze Problems Found in Hydraulic and Pneumatic Systems		X		X				X			X				5
A-9 Use Math and Thermodynamics to Analyze Problems Found in Industrial Heat Treating Systems		X		X				X			X				5
A-10 Use Math, the Physics of Electromagnetism and Optics to Analyze Industrial Systems		X		X							X				3
A-11 Use Math, Physics, and Chemical Measurements to Determine Physical Quantities		X		X							X				3
A-12 Use Math and Chemical Measurements to Determine Compounds, Solutions, or Mixtures		X		X											2
A-13 Use Proper Lab Procedures to Test Chemicals Used in Industrial Processes		X		X											2
A-14 Use Chemical Formulas to Predict and Analyze Reactions in Industrial Processes		X		X											2
A-15 Use Proper Laboratory Methods to Test the Properties of Elements and Compounds		X		X											2
A-16 Apply the Knowledge of Electrochemical Effects to Analyze Chemical Industrial Processes				X		X									4
A-17 Apply Properties of Water to Analyze Industrial Water Treatment Processes		X		X		X	X								4
B. USE DRAWINGS TO ANALYZE AND REPAIR SYSTEMS															
B-1 Use Symbols, Organization, and Engineering Values on Mechanical Drawings		X	X		X	X	X	X	X		X				4
B-2 Use Symbols, Organization, and Engineering Values on Electrical Drawings		X	X		X	X	X	X	X		X				5
B-3 Use Symbols, Organization and Engineering Values on Electronic Drawings		X	X		X	X	X	X	X		X				5
B-4 Use Symbols, Organization and Engineering Values on Fluid Power Drawings		X	X					X	X		X				5
B-5 Use Symbols, Organization and Engineering Values on Digital Drawings		X	X		X		X		X		X				5
C. USE CALIBRATED MEASURING INSTRUMENTS TO TEST/CALIBRATE COMPONENTS															
C-1 Apply Machine Tool Metrology and Measurement Instruments to Align Machine Tools		X	X				X	X		X	X				3
C-2 Apply Electrical Measurement Knowledge and Instruments to Test/Calibrate Electrical Circuits		X	X			X	X	X	X		X				4
C-3 Apply Electronic Measurement Knowledge and Instruments to Test/Calibrate Electronic Circuits		X	X			X	X	X	X		X				4
C-4 Apply Fluid Power Measurement and Instruments to Test/Calibrate Hydraulic and Pneumatic Systems		X	X			X	X	X	X		X				4
C-5 Apply Digital Electronic Measurement Knowledge and Instruments to Test/Calibrate Digital Electronic Circuits		X	X		X	X	X	X	X		X				4

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Technical Workplace Competencies/Course

CROSSWALK

TECHNICAL COMPETENCY
AUTOMATED EQUIPMENT TECHNICIAN (CIM)

	Technical Skills	Manufacturing Calculations	Blueprint Symbology	Manufacturing Processes	Industrial Programming	Industrial Electricity	Motion Control/Servo	Fluid Power Technology	Programmable Logic Control	Machine Technology	Flexible Manufacturing				EXIT PROFICIENCY LEVEL
D. EXPLAIN TEST RESULTS TO TEAM LEADERS, ENGINEERS, CUSTOMERS, AND OTHER TECHNICIANS															
D-1 Use Written English Language; Write Complete Proper Sentences	X			X	X	X	X	X			X				4
D-2 Use Written English Language to Effectively Communicate Results of Technical Tests and Instruments	X		X	X	X	X	X	X	X		X				3
D-3 Use a Word Processor; Obtain Information from Various Sources and Write Effective Reports	X				X						X				3
D-4 Use Spoken English Language to Communicate Feelings, Thoughts, Ideas, and Technical Information	X			X	X	X	X	X			X				4
E. RESOLVE SYSTEM FAILURES WITH CRITICAL THINKING, TROUBLESHOOTING, THEORY AND METROLOGY															
E-1 Identify Nature/Purpose of a System, Subsystem, Module, or Component in a Complex Manufacturing Machine/Process	X		X	X	X	X	X	X	X	X	X				4
E-2 Apply Theory to Predict Behavior of a Complex Manufacturing Machine or Process	X	X	X	X	X	X	X	X	X	X	X				4
E-3 Measure Complex Manufacturing Machine/Process to Determine if Meeting Theoretical Expectations	X	X	X	X	X	X	X	X	X	X	X				4
E-4 Analyze Results to Determine if System, Subsystem, Module, or Component is Meeting Manufacturer's Specifications	X	X	X	X	X	X	X	X	X	X	X				4
E-5 Apply Critical Thinking to Determine if System is Malfunctioning or if Process Must be Reapplied	X	X	X	X	X	X	X	X	X	X	X				5
E-6 Validate the Process and Apply Corrective Action	X	X	X	X	X	X	X	X	X		X				5
E-7 If Corrective Action Does Not Result in Repair of System, Reapply the Process	X	X	X	X	X	X	X	X	X		X				4
F. USE TECHNIQUES TO ISOLATE MALFUNCTION OF ELECTRONIC SYSTEMS															
F-1 Calculate, Predict, and Measure the Response of Quantities in DC Circuits		X	X			X	X				X				4
F-2 Calculate, Predict, and Measure the Response of Quantities in AC Circuits		X	X			X	X				X				4
F-3 Calculate, Predict, and Measure Impedance and Phase Angle in AC Circuits		X	X			X	X				X				4
F-4 Calculate, Predict, and Measure Quantities in Polyphase AC Circuits		X	X			X	X				X				4
F-5 Properly Set-up, Calibrate, and Use Meters and Oscilloscopes		X	X			X	X				X				5
F-6 Use Components Such as Resistors, Inductors, and Capacitors; Construct Circuits and Test Components		X	X			X	X				X				3
F-7 Use Meters/ Oscilloscopes to Measure Phase Shift or Angle in Series Resistive-Capacitive/Resistive-Inductive AC Circuits		X	X			X	X				X				4
F-8 Apply Electromagnetism Theory to Determine Operational Characteristics of Relays, Solenoids, Transformers, and Electrical Motors for DC and AC Circuits		X	X			X	X				X				4
F-9 Use Meters and Oscilloscopes to Test Magnetically Coupled Devices		X	X			X	X				X				4
F-10 Apply Principles of DC Electrical Motors to Identify Types of DC Motors		X	X			X	X				X				4
F-11 Apply Principles of AC Electrical Motors to Identify AC Motors		X	X			X	X				X				4
F-12 Use Rules of Semiconductor Devices and Meters or Oscilloscopes to Test Diodes		X	X			X	X				X				4
F-13 Use Meters or Oscilloscopes to Test Bipolar Transistors and Power MOSFETs		X	X			X	X				X				3
F-14 Use Meters/Oscilloscopes to Test Power Control Semi-Conductors and Their Triggering Devices		X	X			X	X				X				3
F-15 Use Meters/Oscilloscopes to Test Power Supply Circuits, Including Rectifiers/Filtering Circuits for 1 and 3 Phase DC Power Supplies		X	X			X	X				X				4
F-16 Use Schematics and Meters or Oscilloscopes to Identify, Replace and/or Troubleshoot and Repair, Series, Shunt, and Switching Semiconductor, DC Power Supply, Regulator Circuits		X	X			X	X				X				3

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Technical Workplace Competencies/Course

CROSSWALK

TECHNICAL COMPETENCY
AUTOMATED EQUIPMENT TECHNICIAN (CIM)

	Technical Skills	Manufacturing Calculations	Blueprint Symbology	Manufacturing Processes	Industrial Programming	Industrial Electricity	Motion Control/Servo	Fluid Power Technology	Programmable Logic Control	Machine Technology	Flexible Manufacturing				EXIT PROFICIENCY LEVEL
F-17 Use Schematics and Meters or Oscilloscopes to Differentiate Between Various Types of DC Motor Control Circuits and Replace and/or Troubleshoot and Repair These Motor Controls		X	X			X	X				X				3
F-18 Use Schematic Diagrams and Meters or Oscilloscopes to Identify Advanced Motor Controls That Contain Newer Types of Semiconductor Devices, to Troubleshoot and Repair These Motor Controls		X	X			X	X				X				3
F-19 Apply Semiconductor Theory and Amplifier Concepts to Troubleshoot and Replace or Repair the Module Containing the Circuit		X	X			X	X				X				3
F-20 Use Schematic Diagrams and Meters or Oscilloscopes to Test Electrical Devices		X	X			X	X				X				4
F-21 Use Schematic Diagrams and Meters or Oscilloscopes to Test Sensors		X	X			X	X				X				4
G. MEASURE/ISOLATE MALFUNCTIONS OF MECHANICAL/FLUID POWER SYSTEMS															
G-1 Know the Purpose and Use of Major Systems That Comprise a Hydraulic/Pneumatic System to Troubleshoot Components or Systems		X	X	X				X			X				4
G-2 Apply Purpose and Use of Valves in a Hydraulic or Pneumatic System to Troubleshoot Components or Systems			X	X				X			X				4
F-3 Use Formulas and Mathematics to Calculate Quantities in Hydraulic and Pneumatic Systems		X	X	X				X			X				3
G-4 Use Fluid Power Measuring Instruments to Test the Operating Condition of the Fluid Power System				X				X			X				3
G-5 Test the Condition and Behavior of Fluids in a Fluid Power System				X				X			X				3
G-6 Use the Knowledge of Flow; Measure Flow in a Fluid Power System				X				X			X				4
G-7 Calculate, Measure, and Troubleshoot Hydraulic and Pneumatic Accumulators		X	X	X				X			X				3
G-8 Apply Hydraulic, Pneumatic, and High Vacuum Systems Knowledge to Test, Troubleshoot, and Repair Special Components/Devices		X	X	X		X	X	X			X				2
G-9 Identify, Assemble, Measure, and Apply Knowledge of Operating Characteristics of Selected, Specialized Fluid Power Circuits		X	X	X		X	X	X			X				3
G-10 Identify, Assemble, Measure, and Apply Knowledge of Operating Characteristics of Electrically Operated, Specialized Fluid Power Circuits		X	X	X		X	X	X			X				3
G-11 Understand and Use Proper Instruments and Troubleshooting Methods for Fluid Power Circuits						X	X	X			X				4
G-12 Use Laws of Simple Machines and Physics to Identify and Troubleshoot Complex Machines		X	X	X							X				3
G-13 Use Laws of Simple Machines and Physics to Troubleshoot Gearing Systems		X	X	X							X				3
H. APPLY COMPUTER SCIENCE TO COMPUTER CONTROLLED INDUSTRIAL EQUIPMENT															
H-1 Convert Mathematical Quantities in Digital Numbering Systems		X			X				X		X				4
H-2 Perform Mathematical Operations in Digital Numbering Systems		X			X				X		X				2
H-3 Read Digital Symbology and Relate it to Control of Digitally Operated Equipment			X		X				X		X				4
H-4 Express a Complex Logic Problem in Boolean, and Convert it into Symbolic Logic	X		X		X				X		X				3
H-5 Solve Digital Logic Circuits and Ladder Diagrams in Electrical and Programmable Logic Control Circuits	X		X		X				X		X				3
H-6 Express a Complex Logic Problem in Boolean and Convert it into Ladder Logic	X		X		X				X		X				3
H-7 Use Various Programming Devices and Boolean Algebra to Program Computer Controlled Industrial Equipment	X				X				X		X				3
H-8 Use Various Programming Concepts to Program Industrial Equipment	X				X				X		X				3
I. CORRECT MALFUNCTIONS IN PLC CONTROLLED INDUSTRIAL EQUIPMENT															
I-1 Use a Data Entry Device to Set Up and Configure a PLC/PIC to Control Digital and Analog Input/Output Points	X				X				X		X				3

Technical Workplace Competencies/Course

CROSSWALK

TECHNICAL COMPETENCY
AUTOMATED EQUIPMENT TECHNICIAN (CIM)

	Technical Skills	Manufacturing Calculations	Blueprint Symbology	Manufacturing Processes	Industrial Programming	Industrial Electricity	Motion Control/Servo	Fluid Power Technology	Programmable Logic Control	Machine Technology	Flexible Manufacturing				EXIT PROFICIENCY LEVEL
I-2 Set Up/Configure PIC/PLC as Part of the Control System of CNC Machine/Robot to Control Digital and Analog I/O Points		X	X		X	X	X	X	X	X	X				3
I-3 Use Equipment Manuals, Manufacturer's Specifications, and Data Entry/Monitoring Devices to Connect and Test Digital and Analog I/O Points on a PLC or PIC		X	X		X	X	X	X	X	X	X				3
I-4 Use Equipment Manuals, Manufacturer's Specifications, and Data Entry/Monitoring Devices to Test and Troubleshoot Set Up of a PLC or PIC System and Solve Control Problems		X	X		X	X	X	X	X		X				3
J. RESOLVE MALFUNCTIONS FOUND IN COMPUTER SYSTEMS CONTROLLING MANUFACTURING PROCESSES															
J-1 Operate Different Classes of Personal Computers					X				X		X				3
J-2 Maintain Hardware/Software of a Personal Computer					X				X		X				3
J-3 Configure and Troubleshoot Communications Interfaces					X				X		X				3
J-4 Test the Hardware of a Personal Computer					X				X		X				3
K. ASSEMBLE/DISASSEMBLE MECHANICAL, ELECTRICAL, ELECTRONIC, AND COMPUTER SYSTEMS															
K-1 Safely Assemble or Disassemble Mechanical Systems Such as Gearing Systems, Shafts, Couplings, Pulleys, Belts	X		X								X				3
K-2 Adjust Mechanical Systems Such as Gearing Systems, Shafts, Couplings, Pulleys, and Belts	X		X								X				3
K-3 Safely Assemble or Disassemble Subsystems or Components of Fluid Power Systems	X		X								X				4
K-4 Adjust Subsystems or Components of Fluid Power Systems		X	X	X				X			X				4
K-5 Safely Assemble or Disassemble Electrical Systems or Components			X			X	X				X				4
K-6 Adjust Electrical Systems or Components			X			X	X				X				4
K-7 Safely Assemble or Disassemble Electronic Systems or Components	X		X			X	X				X				4
K-8 Safely Adjust Electronic Systems or Components Such as Closed Loop Motor Control Modules, Servo Systems, and Proportional Band Integral Derivative Controls	X	X	X			X	X	X			X				3
K-9 Safely Assemble or Disassemble Digital Systems or Components Such as PLCs, CNCs or Computers	X	X	X		X	X	X		X		X				3
L. USE TEAMWORK TO ACCOMPLISH JOB TASKS AND CONTRIBUTE TO THE SUCCESS OF THE COMPANY															
L-1 Participate in Team Projects and Contribute to Success of the Team and the Project	X	X	X	X	X	X	X	X	X		X				4
L-2 Participate as a Member of Manufacturing Enterprise and Contribute to Success of the Company	X										X				4
L-3 Apply Cooperation and Self Management Techniques to Work with Members of the Team and Accomplish Tasks	X	X	X	X	X	X	X	X	X		X				4

AUTOMATED EQUIPMENT TECHNICIAN/CIM
TECHNICAL WORKPLACE COMPETENCIES
EXIT LEVEL PROFICIENCY MATRIX

Automated Equipment Technician/CIM:

operates, programs, maintains, and repairs automated machine tools and automated manufacturing processes.

The following matrix identifies the five exit levels of technical workplace competencies for the Automated Equipment Technician/CIM Certificate at San Diego City College, Center for Applied Competitive Technologies, San Diego, California.

	EXIT LEVEL OF PROFICIENCY				
Technical Workplace Competency	**1**	**2**	**3**	**4**	**5**
	rarely	routinely with supervision	routinely with limited supervision	routinely without supervision	initiates/ improves/ modifies and supervises others

THE MAST SCANS/COURSE CROSSWALK

The Secretary's Commission on Achieving Necessary Skills (SCANS), U. S. Department of Labor, has identified in its "AMERICA 2000 REPORT' the following five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance:

COMPETENCIES:

Resources: Identifies, organizes, plans, and allocates resources
Interpersonal: Works with others
Information: Acquires and uses information
Systems: Understands complex inter-relationships
Technology: Works with a variety of technologies

FOUNDATION SKILLS:

Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks
Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons
Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty

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Recognizing the value of SCANS proficiencies to job performance, as well as the growing mandate in many states to include SCANS activities in course curricula, MAST asked survey respondents to review the SCANS skill sets in the context of the draft skill standards for each occupational specialty area. MAST also incorporated evaluation of SCANS competencies and foundation skills into its assessment of the pilot training curricula. The results were summarized in a crosswalk that allowed MAST staff to modify course content where needed to strengthen achievement of SCANS competencies.

The following pages present the SCANS/Course Crosswalk for the pilot curriculum in Courses are listed along the top and SCANS competencies and foundations are shown along the left side of the matrix. An exit level proficiency matrix for SCANS competencies and foundation skills is provided as well.

As "soft" skills, the SCANS competencies are inherently difficult to quantify. MAST realizes that some faculty will emphasize the SCANS more or less than others. The SCANS/Course Crosswalk matrix has been included with this course documentation to show the importance of these "soft skills" and the importance of their being addressed in the classroom (particularly in technical classes). In time, faculty will learn to make these types of SCANS activities an integral and important part of the teaching process.

Included on the following pages is the SCANS/Course Crosswalk for the pilot program curriculum. This crosswalk validates the fact that the "soft skills" (SCANS) which were identified by industry as being necessary for entry level employees have been incorporated into the development of the course syllabi. Also included is a matrix which defines the exit level of proficiency scale (1-5).

SCANS/COURSE CROSSWALK

The skill survey incorporated a modified version of the five work-related competencies and three foundation skills identified in the 1991 Report of the Secretary of Labor's Commission on Achieving Necessary Skills (SCANS). Industry respondents were asked to review two SCANS skill sets -- i.e., Skills and Knowledge, and Traits and Attitudes -- presented in the context of the draft Automated Equipment Technician/CIM skill standards. The composite SCANS skill sets have been incorporated into the courses being piloted by San Diego City College. Findings regarding SCANS in relation to both the Competency Profiles and the pilot courses are discussed below.

SCANS and the Competency Profiles

All of the surveyed companies desired the following set of Skills and Knowledge in prospective workers:

-- communication skills
-- use measurement tools
-- use inspection devices
-- mathematical skills
-- reading/writing skills
-- knowledge of safety regulations
-- practice safety in the workplace
-- organizational skills
-- knowledge of company policies/procedures
-- mechanical aptitude
-- ability to comprehend written/verbal instructions
-- basic knowledge of fasteners
-- ability to work as part of a team
-- converse in the technical language of the trade
-- knowledge of occupational opportunities
-- knowledge of employee/employer responsibilities
-- knowledge of company quality assurance activities
-- practice quality-consciousness in job performance

To the above list, several companies added:

-- knowledge of computers (Davis Technologies)
-- CAD/CAM experience (Davis Technologies)
-- manual machining experience (Davis Technologies)
-- ability to go into a company and continuously train others (Eaton Leonard)
-- ISO 9000 (Eaton Leonard)
-- clear/concise writing and communication skills (Eaton Leonard)
-- internal and external proposal writing (Eaton Leonard)
-- clearly communicate technical language (Eaton Leonard)
-- use of computers for design, product development, and word processing (Eaton Leonard)
-- leadership skills (NASSCO)

-- self-management (NASSCO)
-- flexible leadership (NASSCO)
-- basic soldering or surface mount technology (NASSCO)

All of the companies identified the following set of desired Traits and Attitudes in prospective workers:

-- strong work ethic
-- interpersonal skills
-- punctuality
-- dependability
-- honesty
-- neatness
-- safety conscientiousness
-- motivation
-- responsibility
-- physical ability
-- professionalism
-- trustworthiness
-- customer relations
-- personal ethics

To the above list, several companies added:

-- eagerness to learn (Davis Technologies)
-- ability to think (Rohr)
-- willingness to continue education (Rohr)
-- environmental concerns (Teledyne Ryan)

Appendix A contains a detailed list of SCANS competencies and skills by individual company profile.

SCANS and the MAST Courses

The SCANS skills and competencies have been cross walked to individual courses in the Automated Equipment Technician/CIM certificate program being piloted at San Diego City College in 1995-96.

As with the Technical Competency crosswalk, course titles are listed across as columns (e.g., "Manufacturing Calculations") and competencies (e.g., "participates as a member of a team") as rows. Boxes containing a symbol indicate the task is covered by the instructor during the course. The numbers 1-5 found in the Exit Proficiency Level Scale in the far right column indicate the proficiency expected on the part of the student, with 5 as the highest level of proficiency. The MAST scale used by other partners has been modified by the instructor/subject matter expert to reflect the degree of attention given to a specific task within a course.

The crosswalk is intended to serve as an aide to other instructional designers and students in community college programs across the nation.

Companies on Worker Characteristics

Interviewees were often prompted by discussion of the SCANS list to consider the personal characteristics desired in entry-level workers. Their observations were often striking and a selection of their comments is provided below:

- -- Experience with conventional machines is helpful to understanding how computer controlled machines operate.
- -- Applicants should have a feel for making things and not just the ability to follow manufacturing specifications.
- -- The ability to work with people and communicate well is becoming critical in today's team-based cellular manufacturing arrangements.
- -- An understanding of how to perform basic math calculations and skills, even where machines are automated, helps the technician to monitor the operations when they are malfunctioning.
- -- Being TQM- and team-oriented is essential to handling the purchase order certification requirements imposed on contractors today (e.g., ISO-9000, GE-S1OOA).

Page 1

SCANS/Course

CROSSWALK

TECHNICAL COMPETENCIES
AUTOMATED EQUIPMENT TECHNICIAN (CIM)

COMPETENCY	Teamwork Skills	Manufacturing Calculations	Blueprint Symbology	Manufacturing Processes	Industrial Programming	Industrial Electricity	Motion Control/Servo	Fluid Power Technology	Programmable Logic Control	Machine Technology	Flexible Manufacturing				EXIT PROFICIENCY LEVEL
(RS) RESOURCES:															
A. Allocates time	x	x	x	x	x	x	x	x	x	x	x				4
B. Allocates money	x	x	x								x				2
C. Allocates material and facility resources	x									x	x				3
D. Allocates human resources	x										x				3
(IN) INTERPERSONAL SKILLS:															
A. Participates as a member of a team	x	x	x	x	x	x	x	x	x	x	x				4
B. Teaches others	x	x	x	x	x	x	x	x	x	x	x				4
C. Serves clients/customers	x	x	x	x	x	x	x	x	x	x	x				4
D. Exercises leadership	x	x	x	x	x	x	x	x	x	x	x				4
E. Negotiates	x	x	x	x	x	x	x	x	x	x	x				4
F. Works with cultural diversity	x	x	x	x	x	x	x	x	x	x	x				4
(IF) INFORMATION SKILLS:															
A. Acquires and evaluates information	x	x	x	x	x	x	x	x	x	x	x				4
B. Organizes and maintains information	x	x	x	x	x	x	x	x	x	x	x				4
C. Interprets and communicates information	x	x	x	x	x	x	x	x	x	x	x				4
D. Uses computers to process information		x	x		x				x		x				3
(SY) SYSTEMS:															
A. Understands systems	x	x	x	x	x	x	x	x	x	x	x				5
B. Monitors and corrects performance	x	x	x	x	x	x	x	x			x				4
C. Improves and designs systems	x	x	x	x	x	x	x	x	x		x				4
(TE) TECHNOLOGY:															
A. Selects technology	x	x	x	x	x	x	x	x	x	x	x				5
B. Applies technology to task	x	x	x	x	x	x	x	x	x	x	x				5
C. Maintains and troubleshoots technology	x	x	x	x	x	x	x	x	x	x	x				5

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SCANS/Course

CROSSWALK

TECHNICAL COMPETENCIES
AUTOMATED EQUIPMENT TECHNICIAN (CIM)

FOUNDATION SKILLS	Teamwork Skills	Manufacturing Calculations	Blueprint Symbology	Manufacturing Processes	Industrial Programming	Industrial Electricity	Motion Control/Servo	Fluid Power Technology	Programmable Logic Control	Machine Technology	Flexible Manufacturing				EXIT PROFICIENCY LEVEL
(BS) BASIC SKILLS:															
A. Reading	X	X	X	X	X	X	X	X	X	X	X				4
B. Writing	X	X	X	X	X	X	X	X	X	X	X				4
C. Arithmetic and mathematics	X	X	X	X	X	X	X	X	X	X	X				4
D. Listening	X	X	X	X	X	X	X	X	X	X	X				3
E. Speaking	X	X	X	X	X	X	X	X	X	X	X				3
(TS) THINKING SKILLS:															
A. Creative thinking	X	X	X	X	X	X	X	X	X	X	X				5
B. Decision making	X	X	X	X	X	X	X	X	X	X	X				4
C. Problem solving	X	X	X	X	X	X	X	X	X	X	X				5
D. Seeing things in the mind's eye	X	X	X	X	X	X	X	X	X	X	X				5
E. Knowing how to learn	X	X	X	X	X	X	X	X	X	X	X				4
F. Reasoning	X	X	X	X	X	X	X	X	X	X	X				5
(PQ) PERSONAL QUALITIES:															
A. Responsibility	X	X	X	X	X	X	X	X	X	X	X				3
B. Self-esteem	X	X	X	X	X	X	X	X	X	X	X				3
C. Social	X	X	X	X	X	X	X	X	X	X	X				3
D. Self-management	X	X	X	X	X	X	X	X	X	X	X				4
E. Integrity/honesty	X	X	X	X	X	X	X	X	X	X	X				3

SCANS
COMPETENCIES AND FOUNDATION SKILLS
EXIT LEVEL PROFICIENCY MATRIX

The Secretary's Commission on Achieving Necessary Skills (SCANS), U. S. Department of Labor, has identified in its "AMERICA 2000 REPORT' the following five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance:

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Systems: Understands complex inter-relationships
Technology: Works with a variety of technologies

FOUNDATION SKILLS:

Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks
Thinking Skills: Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons
Personal Qualities: Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.

The following matrix identifies the five exit levels of proficiency that are needed for solid job performance.

EXIT LEVEL OF PROFICIENCY					
SCANS Competencies and Foundation Skills	**1**	**2**	**3**	**4**	**5**
	rarely	routinely with supervision	routinely with limited supervision	routinely without supervision	initiates/ improves/ modifies and supervises others

THE MAST COURSE SYLLABI
"PILOT PROGRAM"

MAST has produced a very unique set of course outlines, driven and validated by industry and encompassing the broad range of technologies covered by the MAST grant. The course outlines also include proposed SCANS activities that will be useful to an instructor in preparing students to enter the workforce of the future.

Included in the following pages are final course outlines developed and refined in the process of piloting the MAST training programs. The outlines include a brief course description; required course materials (e.g., textbook, lab manual, and tools, if available); proposed method of instruction; proposed lecture and lab outlines; and detailed course objectives for both Technical Workplace Competencies and SCANS Competencies.

These outlines were completed and revised during the second year of MAST, following completion of the pilot phase. The outlines are intended to serve as an aide to other instructional designers and faculty in community college programs across the nation.

Included on the following pages are the Course Syllabi for each of the courses which were taught during the pilot program.

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

MANUFACTURING METRICS AND CALCULATIONS

MAST PROGRAM
COURSE SYLLABUS
MANUFACTURING METRICS AND CALCULATIONS

Lecture hours/week: 2 **Lab hours/week: 3** **Credit hours: 3**

COURSE DESCRIPTION:

This course covers basic application of mathematical concepts required for effective performance as an automation technician or machine technologist in the machine tool industry. Problem examples will be taken from machines and equipment that are typically found in the modern industrial manufacturing facility. Associate Degree Credit

PREREQUISITES: **Eligibility for Elementary Algebra and College Reading Study Skills**

COURSE OBJECTIVES:

Upon successful completion of this course, the student will be able to:

1. Use scientific notation and engineering notation to express mathematical values that are given or obtained by measurement, and apply these mathematical values to the solution of technical problems
2. Use algebraic formulas such as those used in machining technology, electronics, electricity, fluid power, and technical physics, and apply scientific notation or engineering notation values to the solution of these equations to aid in solving technical problems
3. Apply algebraic formulas such as those found in machining technology, electronics, electricity, fluid power, and technical physics, to identify the effects on a system of a change in a variable of the equation
4. Transpose variables from one side of a formula to the other side of the formula to produce new relationships in the equation, and identify the relationship between the variables of the formula and the real world value that the variable represents
5. Use the Cartesian (rectangular) coordinate system to identify quadrants and points in the system, and plot coordinates on the grid for lines and curves
6. Use the rules of geometry to solve problems involving surface area and perimeters of geometric shapes, such as rectangles, squares, triangles, trapezoids, parallelograms, and circles
7. Use the rules of solid geometry to solve problems involving the volume and surface area of geometric shapes such as cubes, right angle solids, cylinders, prisms, cones, and spheres
8. Use the rules of trigonometry to solve simple vectors, find the angle formed by two measured line segments, calculate a dimension given an angle and other dimension, and plot the sine and cosine functions through 360 degrees on a Cartesian coordinate grid

REQUIRED COURSE MATERIALS:

Textbook: An example of an appropriate text would be Elementary Technical Mathematics by Ewen/Nelson Fifth Edition, 1991

Lab Materials: Practical mathematical problem solving examples for in-class exercises

METHODS OF INSTRUCTION:

Lecture: Presentations will include lecture, demonstration, and group problem solving.

Laboratory: Laboratory will be "hands-on" mathematical problem solving.

Group Projects: Group math projects will be assigned during the lab periods. Each set of projects will provide practice in one or more mathematical concepts. The students will work on problems that are derived from manufacturing or industrial situations. Any problems not solved by the team will be assigned as homework problems. The individual grade for these tasks will be a combination of a team grade, and a team assessment of the individual's contribution to the team's efforts. The instructor will devise a method whereby the team's assessment of an individual's contributions is fair and free of bias.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. perform on written or oral examinations
2. perform on outside assignments
3. contribute to group problem solving
4. apply theory to problem solving
5. maintain attendance as per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Geometry and the History of Mathematics		
A. The role of problem solving and the building of cities and monuments by our ancestors in the creation of mathematics and geometry		
B. The creation of rules and formulas		
C. Using letters to represent mathematical concepts		
D. Plane geometry		
E. Applications of plane geometry to the solution of technical problems		
F. Solid geometry		
G. Applications of solid geometry to the solution of technical problems		

H. The rectangular (Cartesian) coordinate system

Trigonometry

A. The history of the usage of trigonometry
B. The right triangle
C. Trigonometric functions of the right triangle (sine, cosine, tangent)
D. Using trigonometric functions to solve technical problems
E. Graphical representations of trigonometric functions

The Decimal Numbering System

A. Negative and positive numbers
B. The ten base numbering system

The Fifteen Rules of Math

A. Definitions
B. The rules of addition, subtraction, multiplication, and division of positive and negative numbers
C. The addition, subtraction, multiplication, and division axioms
D. The order of operations
E. The associative rule
F. The distributive rule
G. The identity rule
H. A number multiplied by its reciprocal
I. A number multiplied or divided by zero
J. Coefficients and coefficients of one
K. A number raised to the zero power or first power
L. Operations with exponentiated numbers

Scientific and Engineering Notation

A. Scientific notation
B. Engineering notation

Algebra

A. Algebraic expressions
B. Algebraic operations: addition, subtraction, multiplication, and division
C. Algebraic operations: factoring
D. Algebraic fractions
E. Equations
    1) Transposing algebraic equations
    2) Solving algebraic equations
    3) Solving two linear equations in two unknowns
F. Graphing algebraic equations
    1) Graphing linear equations
    2) Graphing equations in two unknowns

Formulas

A. Using formulas to express physical concepts
B. Deriving new concepts by transposing formulas

C. Solving problems with the use of formulas (word problems)

Estimating Problems —

Total Lecture Hours

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

Upon successful completion of this course the student will be able to:

A. USE SCIENTIFIC NOTATION AND ENGINEERING NOTATION TO EXPRESS MATHEMATICAL VALUES THAT ARE GIVEN OR OBTAINED BY MEASUREMENT, AND APPLY THESE MATHEMATICAL VALUES TO THE SOLUTION OF TECHNICAL PROBLEMS

1. Explain the Rules of a Base Ten Numbering System
2. Explain the Rules of Scientific Notation
3. Apply the Rules of Exponents to the Conversion of Ordinary Base Ten Numbers to Scientific Notation
4. Solve Multiplication, Division, Exponential, and Nth Root Problems Using Scientific Notation
5. Explain the Rules of Engineering Notation
6. Convert Numbers Expressed in Scientific Notation to Engineering Notation and Vice-versa
7. Solve Multiplication, Division, Exponential, and Nth Root Problems Using Engineering Notation

B. USE ALGEBRAIC FORMULAS SUCH AS THOSE USED IN MACHINING TECHNOLOGY, ELECTRONICS, ELECTRICITY, FLUID POWER, AND TECHNICAL PHYSICS; AND APPLY SCIENTIFIC NOTATION OR ENGINEERING NOTATION VALUES TO THE SOLUTION OF THESE EQUATIONS TO AID IN SOLVING TECHNICAL PROBLEMS

1. Explain the Properties and Uses of Formulas
2. Substitute Values Expressed in Scientific or Engineering Notation in a Formula
3. Solve the Formula for the Unknown Value

C. APPLY ALGEBRAIC FORMULAS SUCH AS THOSE FOUND IN MACHINING TECHNOLOGY, ELECTRONICS, ELECTRICITY, FLUID POWER, AND TECHNICAL PHYSICS; TO IDENTIFY THE EFFECTS ON A SYSTEM OF A CHANGE IN A VARIABLE OF THE EQUATION

1. Explain the relationship between the variable in a formula and the engineering value that is represented by the variable
2. Explain the principles of direct variation and inverse variation
3. Determine the effects of a change in variables on the results of a formula

D. TRANSPOSE VARIABLES FROM ONE SIDE OF A FORMULA TO THE OTHER SIDE OF THE FORMULA TO PRODUCE NEW RELATIONSHIPS IN THE EQUATION, AND IDENTIFY THE RELATIONSHIP BETWEEN THE VARIABLES OF THE FORMULA AND THE REAL WORLD VALUE THAT THE VARIABLE REPRESENTS

1. Use the Rules of Algebra to Manipulate Values in an Equation
2. Create New Formulas by Transposing Variables in the Formula
3. Identify the Relationship That the New Formula Represents

E. **USE THE CARTESIAN (RECTANGULAR) COORDINATE SYSTEM TO IDENTIFY QUADRANTS AND POINTS IN THE SYSTEM, AND PLOT COORDINATES ON THE GRID FOR LINES AND CURVES**
   1. Identify the Parts of a Rectangular Coordinate System
   2. Use the Rectangular Coordinate System to Plot Lines and Curves

F. **USE THE RULES OF GEOMETRY, TO SOLVE PROBLEMS INVOLVING SURFACE AREA AND PERIMETERS OF GEOMETRIC SHAPES, SUCH AS RECTANGLES, SQUARES, TRIANGLES, TRAPEZOIDS, PARALLELOGRAMS, AND CIRCLES**
   1. Solve Problems Involving Perimeters of Planer Geometric Shapes
   2. Solve Problems Involving Surface Area of Planer Geometric Shapes

G. **USE THE RULES OF SOLID GEOMETRY TO SOLVE PROBLEMS INVOLVING THE VOLUME AND SURFACE AREA OF GEOMETRIC SHAPES SUCH AS CUBES, RIGHT ANGLE SOLIDS, CYLINDERS, PRISMS, CONES, AND SPHERES**
   1. Solve Problems Involving Volumes of Three Dimensional Geometric Shapes
   2. Solve Problems Involving Surface Area of Three Dimensional Geometric Shapes

H. **USE THE RULES OF TRIGONOMETRY TO SOLVE SIMPLE VECTORS, FIND THE ANGLE FORMED BY TWO MEASURED LINE SEGMENTS, CALCULATE A DIMENSION GIVEN AN ANGLE AND ANOTHER DIMENSION, AND PLOT THE SINE AND COSINE FUNCTIONS THROUGH 360 DEGREES ON A CARTESIAN COORDINATE GRID**
   1. Use Trigonometry to Find Lengths
   2. Use Trigonometry to Find Angles
   3. Plot Two or More Trigonometric Functions on a Cartesian Coordinate Grid
   4. Use the Concept of the Unit Circle, and the Trigonometric Sine Function to Plot a Sine Wave on a Cartesian Coordinate Grid

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. **COMPETENCIES**
   A. ***Resources:*** *Identifies, organizes, plans, and allocates resources*
      1. allocates time
         a. completes assigned work on time
         b. successfully completes timed examinations
      2. allocates money

    - a. calculates budget expenses
    - b. calculates costs
    - c. calculates "what if?" projections

- B. *Interpersonal: Works with others*
  - 1. participates as a member of a team
    - a. participates in team math problem solving
    - b. participates in study groups
  - 2. teaches others
    - a. helps team members solve math problems
    - b. contributes information to teams/study groups
  - 3. satisfies instructor assigned requirements
  - 4. exercises leadership
    - a. forms study groups
    - b. motivates teams/study groups to succeed
    - c. expresses ideas, feelings, and opinions clearly
    - d. identifies whether the source of a position is an idea, feeling, or opinion
    - e. provides supporting facts to support positions
  - 5. expresses ideas and listens to others to solve team problems
  - 6. works well with team and class members regardless of race class, ethnicity, or religion
- C. *Information: Acquires and uses information*
  - 1. acquires and evaluates information
    - a. obtains new or complementary information for various sources such as:
      - 1) text books
      - 2) lectures
      - 3) library
      - 4) periodicals
      - 5) internet
    - b. evaluates information for accuracy, challenges information that contradicts logical evaluation
  - 2. keeps and maintains an organized class lab workbook
  - 3. gives oral/written presentations to class
  - 4. uses computers to solve math problems
- D. *Systems: Understands complex inter-relationships*
  - 1. understands systems
    - a. understands systems of numbers
    - b. understands function of math formulas in physical systems
    - c. understands the evolution of mathematics
  - 2. monitors and corrects performance
    - a. evaluates physical systems using mathematical formulas
    - b. corrects systems from results of evaluation
  - 3. finds alternate methods to solve mathematical problems
- E. *Technology: Works with a variety of technologies*
  - 1. selects technology such as calculator, computer spread sheet, or data base that is appropriate to the solution of a mathematical problem
  - 2. sets up math problems in calculators, computer spread sheet, or data base

3. if calculator or program does not perform as expected, finds problem

II. FOUNDATION SKILLS

A. ***Basic Skills:*** *Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*

1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
   - a. reads assigned course material
   - b. interprets reading material to perform successfully in class
   - c. interprets graphical data from Cartesian coordinate graphs
2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   - a. uses written mathematical symbolic relationships to express concepts
3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   - a. performs mathematical computations using scientific notation
   - b. performs mathematical computations using engineering notation
   - c. applies the principles of plane geometry to solve technical problems
   - d. applies the principles of solid geometry to solve technical problems
   - e. applies the principles of trigonometry to solve technical problems
   - f. applies algebra to understand physical systems, and solve technical problems
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
   - a. actively listens to the information being presented in class and feeds back concepts
   - b. listens to the ideas, feelings, and opinions of fellow classmates
5. ***Speaking:*** *Organizes ideas and communicates orally*
   - a. presents ideas and information in class
   - b. contributes to classroom discussion

B. ***Thinking Skills:*** *Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. ***Creative Thinking:*** *Generates new ideas*
   - a. uses formulas and algebraic mathematics to create new relationships
2. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   - a. uses formulas and algebraic manipulation to predict the limits of behavior of physical systems
   - b. uses formulas and algebraic manipulation to determine alternate/desirable changes in physical systems
3. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
   - a. uses mathematics and formulas to solve problems in physical systems

   b. chooses desired mathematics tools/formulas to indicate plans of action

4. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*

   a. uses algebra and algebraic formulas to visualize the symbolic relationships of physical quantities in physical systems

5. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*

   a. uses effective study techniques to acquire new class material

   b. practices to acquire new skills

6. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*

   a. uses principles of mathematics to create new relationships

*C. **Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*

   a. performs at or above expected class level

   b. sets individual/group goals and accomplishes them.

2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*

   a. contributes to classroom discussion with original ideas

   b. maintains a positive sense of humor that is not at the expense of another person's sense of self worth

3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*

   a. allows divergent views in class discussions

   b. responds positively to new ideas

   c. supports the worthwhile goals and objectives of the team and fellow classmates

4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*

   a. aAccepts responsibility for completion of assigned work

   b. sets individual/group goals and accomplishes them

   c. maintains a record of accomplishments

5. ***Integrity/Honesty:*** *Chooses ethical courses of action*

   a. performs own work when required, does not plagiarize the work of others

   b. protects school property

   c. does not misappropriate the property of the school or other classmates

   d. reports infractions of school rules to school authorities

Appropriate Reference Materials:

1. Technical Mathematics with Calculus by Peterson, 1994

***M**achine Tool **A**dvanced **S**kills*
***T**echnology Program*

MAST

COURSE SYLLABUS

TEAMWORK SKILLS

MAST PROGRAM
COURSE SYLLABUS
TEAMWORK SKILLS

Lecture hours/week: 0 **Lab hours/week: 3** **Credit hours: 1**

COURSE DESCRIPTION:

This course covers basic application of team problem solving concepts and techniques required for effective performance as a member of problem solving team in the business environment.

PREREQUISITES: **Eligibility for College Reading Study Skills**

COURSE OBJECTIVES:

Upon successful completion of this course, the student will be able to:

1. Recall the ***six steps*** of the problem-solving process, including:
    - A. identifying the problem
    - B. analyzing the cause of the problem
    - C. creating options for solutions
    - D. selecting the best solution
    - E. implementing the solution
    - F. evaluating the success of the solution
2. ***Select*** and ***use*** effective techniques to define, analyze and solve problems, including:
    - A. brainstorming
    - B. clarifying
    - C. combining
    - D. consensus
    - E. force field analysis
    - F. NGT
    - G. criteria rating
    - H. defining the problem
    - I. circle and define
    - J. cause and effect
    - K. plan analysis
    - L. data gathering
    - M. flow charting
    - N. plan of work
    - O. evaluation procedure
    - P. process monitoring
3. ***Demonstrate*** facilitation skills in team problem-solving situations, including:
    - A. encouraging participation
    - B. modeling attentive listening
    - C. refocusing
    - D. paraphrasing

E. summarizing
F. charting during a meeting

REQUIRED COURSE MATERIALS:

Textbook:	Teamwork Skills participant handout or the Team Handbook by Ken Scholtes
Lab Materials:	One easel pad and stand for each 4-6 students One to two easel pad markers per group of 4-6 students A designated issue for problem solving in class exercises

METHODS OF INSTRUCTION:

Lecture:	Presentations will include lecture and demonstration.
Laboratory:	Group problem solving practice and application on an issue designated by the class.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. contribute to group problem solving
2. apply tools and techniques to problem solving
3. maintain integrity to the problem solving process
4. keep all team members participating and focused when leading/facilitating the team

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. ***Resources:*** *Identifies, organizes, plans, and allocates resources*
  1. allocates time
    a. completes assigned work on time
  2. allocates money
    a. calculates costs
    b. calculates "what if" projections

- B. *Interpersonal: Works with others*
    - 1. participates as a member of a team
        - a. participates in team problem solving
    - 2. satisfies instructor assigned requirements
        - a. participates in team problem solving
    - 3. exercises leadership
        - a. maintains problem solving process integrity
        - b. keeps group focused on the issue at hand
        - c. sees to it that all team members participate
        - d. makes time-bounded assignments to team members
- C. *Information: Acquires and uses information*
    - 1. acquires and evaluates information
        - a. organizes data provided in practice exercises into the proper format for analysis or prioritization
    - 2. identifies new relationships in the data
    - 3. gives oral/written presentations to class

II. FOUNDATION SKILLS

- A. *Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*
    - **1.** ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
        - a. reads assigned course material
        - b. interprets reading material to perform successfully in class
        - c. interprets graphical data from Pareto, GANTT, criteria-rating and other charts
    - **2.** ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
        - a. constructs charts, problem statements and lists
        - b. transcribes spoken input from team members onto easel sheets
    - **3.** ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
        - a. performs mathematical computations in assigning priorities in the selection of problems, causes and solutions to focus on
        - b. calculates the financial impact of cost overruns, schedule delinquencies and materials waste
        - c. computes the results of numerical data-gathering, and calculates trends
    - **4.** ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
        - a. actively listens to the information being presented in class and feeds back concepts
        - b. listens to the ideas, feelings, and opinions of fellow team members
        - c. recognizes when team members have digressed and refocuses them
    - **5.** ***Speaking:*** *Organizes ideas and communicates orally*
        - a. presents ideas and information in class

- b. contributes to classroom discussion
- c. participates verbally in teamwork activities and processes

B. ***Thinking Skills:*** *Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. ***Creative Thinking:*** *Generates new ideas*
   - a. nrainstorms on problems, causes and solutions
   - b. interprets data gathered for important trends
   - c. uses "is-is not" techniques for quantifying the characteristics of a problem
2. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
   - a. makes thorough use of consensus, nominal group technique and criteria rating
   - b. develops lists of relevant decision making criteria and a complementary five-point scale for applying them
3. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
   - a. uses a Kepner-Tregoe based six step problem solving process
   - b. practices using and leading a team in the use of all the skills on an issue of their own choosing
   - c. learns to use a time and process-oriented tracking plan for problem solving
4. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
   - a. develops process flow charts to help visualize the breakdowns contributing to the problem
   - b. uses Pareto charts, Cycle-Time Analysis charts and Defect Concentration Diagrams
5. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
   - a. uses effective learning techniques to understand new class material
   - b. actively listens to understand the material
   - c. practices to acquire new skills
6. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
   - a. uses criteria and quantitative and qualitative data to discriminate and choose from a variety of alternatives
   - b. actively listens to understand the material
   - c. practices to acquire new skills

C. ***Personal Qualities:*** *Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
   - a. strictly applies the problem solving protocol
   - b. sets individual and group goals and accomplishes them
   - c. meets time standards
   - d. performs realization calculations to determine the degree of goal achievement accomplished

2. ***Self-Esteem:** Believes in own self-worth and maintains a positive view of self*
    a. contributes to classroom discussion with original ideas
    b. maintains a positive sense of humor that is not at the expense of another person's sense of self worth
    c. participates in rating and ranking exercises constructively
3. ***Sociability:** Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. applies all problem solving skills in constantly changing teams
    b. proactively solicits input from all stakeholders on all aspects of the problem
    c. allows divergent views in class discussions
    d. responds positively to new ideas
    e. shares new and valuable information freely and openly with other members of the team
4. ***Self-Management:** Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. accepts responsibility for completion of assigned work
    b. sets individual/group goals and accomplishes them
    c. maintains a record of accomplishments and the corroborating documentation in the problem solving tracking format
5. ***Integrity/Honesty:** Chooses ethical courses of action*
    a. performs own work when required, does not plagiarize the work of others
    b. protects school property
    c. does not misappropriate the property of the school or other classmates
    d. reports infractions of school rules to school authorities

Appropriate Reference Materials:

1. The Rational Manager by Charles Kepner and Benjamin Tregoe
2. The Team Handbook by Ken Scholtes
3. Proactive Manager

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*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

PRINT READING AND SYMBOLOGY

MAST PROGRAM
COURSE SYLLABUS
PRINT READING AND SYMBOLOGY

Lecture hours/week: 3 **Lab hours/week: 0** **Credit hours: 3**

COURSE DESCRIPTION:

This course involves study of the types of symbols and engineering notations used for mechanical, electrical, electronic, hydraulic, and pneumatic drawings. Representative drawings will be used to demonstrate concepts and practice in interpreting the symbols and notations. Students will view and handle typical parts represented by the symbols. (FT) Associate Degree Credit

PREREQUISITES: **Satisfactory completion with a grade of "C" or better, or concurrent enrollment in Manufacturing Metrics and Calculations, or equivalent**

COURSE OBJECTIVES:

Upon successful completion of this course the student will:

1. Use the symbols and organization associated with mechanical drawings to identify features of the part from the drawing, the part's dimensions, and the tolerance of the part's features, on both standard and Geometric Dimensioning drawings
2. Use the symbols and organization associated with electrical ladder diagrams, or electronic schematic diagrams and electrical/electronic layout diagrams to identify components by their symbol, determine the location of the components, and apply engineering values obtained from the drawing to the solution of technical problems
3. Use the symbols and organization associated with fluid power schematic diagrams, and fluid power layout diagrams, to identify components by their symbol, determine the location of the components, and apply engineering values obtained from the drawing to the solution of technical problems

REQUIRED COURSE MATERIALS:

Textbook: An example of an appropriate text would be a text based upon the most current American National Standards Institute (ANSI) and/or International Standards Organization (ISO) specifications for drawing symbols and engineering notation.

Lab Materials: None

METHODS OF INSTRUCTION:

Lecture: Presentations will include lecture, demonstration, and group problem solving.

Group Projects: Group projects will be assigned during the lab periods. Each set of projects will provide practice in one or more concepts. The students will work on problems that are derived from manufacturing or industrial situations. Any problems not solved by the team will be assigned as homework problems. The individual grade for these tasks will be a combination of a team grade, and a team assessment of the individual's contribution to the team's efforts. The instructor will devise a method whereby the team's assessment of an individual's contributions is fair and free of bias.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. perform on written or oral examinations
2. perform on outside assignments
3. contribute to group problem solving
4. apply theory to problem solving
5. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Mechanical Drawing Symbols		
A. Mechanical drawing symbols		
B. Engineering notation used in mechanical drawings		
C. Examples of mechanical parts that relate to the symbols used		
D. Tolerancing		
E. Geometric Dimensioning and Tolerancing		
F. Application of engineering values		
Electrical Drawings		
A. Electrical drawing symbols		
B. Engineering notation used in electrical drawings		
C. Examples of electrical parts that relate to the symbols used		
D. Ladder diagram organization		
E. Application of engineering values		
Electronic Drawing		
A. Electronic drawing symbols		
B. Engineering notation used in electronic drawings		
C. Examples of electronic parts that relate to the symbols used		
D. Organization of electronic schematics and specifications		

E. Application of engineering values

Hydraulic and Pneumatic Drawings

A. Hydraulic and pneumatic drawing symbols
B. Engineering notation used in hydraulic and pneumatic drawings
C. Examples of hydraulic and pneumatic parts that relate to the symbols used
D. Organization of hydraulic and pneumatic drawings and specifications
E. Application of engineering values

National and International Standards Organizations —

Total Lecture Hours

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

Upon successful completion of this course the student will be able to:

A. USE THE SYMBOLS AND ORGANIZATION ASSOCIATED WITH MECHANICAL DRAWINGS, TO IDENTIFY FEATURES OF THE PART FROM THE DRAWING, THE PART'S DIMENSIONS, AND THE TOLERANCE OF THE PART'S FEATURES, ON BOTH STANDARD AND GEOMETRIC DIMENSIONING DRAWINGS

1. Identify the Types of Lines Used on a Mechanical Drawing and Their Purpose
2. Apply the Concept of a Dimension to an Actual Part
    a. Determine the dimension of a feature of a part from a drawing
    b. Identify the type of dimension from the drawing or the title block
3. Apply the Concept of a Tolerance to a Dimension
    a. Locate the information pertaining to dimensional tolerances on a drawing
    b. Identify the type of tolerance that will be applied to a dimension
    c. Calculate the effects of the size of a dimension when the tolerance is applied
4. Use Engineering Data Obtained from a Drawing to Determine the Manufacturing Processes Employed in the Manufacturing of the Part
    a. Use the tile block to determine if the drawing is an assembly or detail drawing, and a description of the part or assembly
    b. Use information contained in the title block to determine the manufacturing process that will be employed in the manufacturing of the part or assembly
    c. Identify manufacturing operations such as welding, surface finish, and machining from the drawing and the title block
    d. Identify the specifications of manufacturing operations such as welding, surface finish, and machining from the drawing and the title block
    e. Determine the correct drawing and the validity of the drawing from the title block and the revision block
    f. Use general or engineering (flag) notes to detect modifications to the specifications of features of the part or assembly

g. Use the bill of materials block to determine the types of materials that will be used to manufacture the product

h. Use the title block to determine general details of the drawing such as drawing size, company, title, number, and scale

5. Use Geometric Dimensioning and Tolerancing (GD&T) Data to Determine Tolerances and Geometric Characteristics of a Geometric Feature of a Part or Assembly

a. Use the symbology of GD&T to determine a datum plane or datum object

b. Use the symbology of GD&T to determine the geometric characteristics of a feature

c. Use the symbology of GD&T; such as maximum material condition (MMC), least material condition (LMC), and regardless of feature size (RFS), to determine the possible size of a geometric feature

d. Determine the tolerances of a feature from the application of the symbology of GD&T

e. Associate the principles of GD&T with the mathematical concepts of geometry

B. USE THE SYMBOLS AND ORGANIZATION ASSOCIATED WITH ELECTRICAL LADDER DIAGRAMS, OR ELECTRONIC SCHEMATIC DIAGRAMS AND ELECTRICAL/ELECTRONIC LAYOUT DIAGRAMS, TO IDENTIFY COMPONENTS BY THEIR SYMBOL, DETERMINE THE LOCATION OF THE COMPONENTS, AND APPLY ENGINEERING VALUES OBTAINED FROM THE DRAWING TO THE SOLUTION OF TECHNICAL PROBLEMS

1. Identify the Symbols Used to Depict Electrical or Electronic Components in an Electrical or Electronic Diagram

a. Identify basic symbols used to depict electrical or electronic components

1) Resistors
2) Capacitors
3) Inductors
4) Contacts
5) Conduction paths
6) Connected conduction paths
7) Connectors
8) Current zero reference symbols (common, frame ground, circuit return path etc.)
9) Current sources (DC voltage, AC voltage)
10) Direction of flow
11) Circuit breakers
12) Electrical motors, generators
13) Potentiometers

b. Identify composite symbols that contain the components depicted by basic symbols

1) Amplifiers
2) Semiconductors
3) Sensors
4) Relays
5) Switches-wafer, limit, toggle, push button

        6) Transformers
        7) Motion control (feedback) systems
        8) Feedback devices, magnetic, inductive, optical feedback devices
        9) Digital electronic (Boolean) symbols
    c. Explain the use of each component in general terms
2. Relate the Symbols Used in the Depiction of Electrical or Electronic Components with the Actual Components and Their Relative Size and Shape
3. Use Electrical or Electronic Layout Diagrams to Locate the Position and Relative Size of a Component
4. Explain the Layout and Organization of an Electrical Ladder Diagram.
    a. Explain the meaning and use of rungs and rails
    b. Locate the primary power distribution and the ladder control logic
    c. Locate the position on the rungs of relay coils and contacts
    d. Identify wires and wire numbers on a electrical ladder diagram
    e. Identify current sources, their type, and magnitude
5. Explain the Layout and Organization of Electronic Drawings.
    a. Explain the types of drawing and documentation that comprise a set of electronic drawings
    b. Locate components on a electronic schematic drawing
    c. Determine the types of current sources and their magnitude (voltage, AC or DC)
    d. Determine the specifications of the operational characteristics of an electronic assembly from the specifications section of a manual
    e. Relate the electronic symbol to the component number on an electronic schematic diagram
    f. Determine the value of components and their model or type number from the material specification list in the materials section of an electronic assembly from the equipment manual

C. USE THE SYMBOLS AND ORGANIZATION ASSOCIATED WITH FLUID POWER SCHEMATIC DIAGRAMS, AND FLUID POWER LAYOUT DIAGRAMS, TO IDENTIFY COMPONENTS BY THEIR SYMBOL, DETERMINE THE LOCATION OF THE COMPONENTS, AND APPLY ENGINEERING VALUES OBTAINED FROM THE DRAWING TO THE SOLUTION OF TECHNICAL PROBLEMS

1. Identify Symbols Used to Depict Components in a Hydraulic or Pneumatic Schematic Drawing
    a. Identify basic symbols used to depict hydraulic or pneumatic components
        1) Working pressure lines
        2) Pilot lines
        3) Drain lines
        4) Line connections
        5) Tank
        6) Fluid flow direction
        7) Valve body
        8) Ways
        9) Spring
        10) Adjusters
        11) Temperature

        12) Fluid conditioners (filters, separators, oilers)
        13) Heat exchanger
        14) Pumps
        15) Motors
        16) Linear actuators (cylinders)
        17) Flow control valves
        18) Check valves
        19) Miscellaneous symbols such as: accumulator, muffler, Venturi, air bearing, temperature control, or pressure switch
    b. Describe the complex function that are comprised from basic symbols
        1) Valves with complex functions
        2) Pumps with complex functions
        3) Intensifiers
        4) Pressure control valves
        5) Flow control valves with complex functions
        6) Motion devices such as motors and cylinders that have complex functions

2. Relate the Symbols Used in the Depiction of Hydraulic or Pneumatic Components with the Actual Components and Their Relative Size and Shape
3. Use Hydraulic or Pneumatic Layout Diagrams to Locate the Position and Relative Size of a Component
4. Explain the Layout and Organization of a Hydraulic or Pneumatic Diagram
    a. Explain the meaning and use of manifolds or enclosures
    b. Locate the pumping and tank systems
    c. Locate the fluid conditioning systems
    d. Locate the control valves
    e. Identify motion actuators, rotary and linear
5. Explain the Layout and Organization of Hydraulic or Pneumatic Drawings
    a. Explain the types of drawing and documentation that comprise a set of hydraulic or pneumatic drawings
    b. Locate pressure and flow controls on a hydraulic or pneumatic schematic drawing
    c. Determine the types of pressures and flows and their magnitude

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. ***Resources:** Identifies, organizes, plans, and allocates resources*
   1. allocates time
      a. completes assigned work on time
      b. successfully completes timed examinations
   2. allocates money
      a. determines the cost of components
      b. using the specifications for a component, determines equal or better components at lower cost

B. ***Interpersonal:** Works with others*
   1. participates as a member of a team
      a. participates in team projects involving application of component symbols to actual systems or devices
      b. participates in study groups
   2. teaches others
      a. helps team members solve problems
      b. contributes information to teams/study groups
   3. satisfies instructor assigned requirements
   4. exercises leadership
      a. forms study groups
      b. motivates teams/study groups to succeed
      c. expresses ideas, feelings, and opinions clearly
      d. identifies whether the source of a position is an idea, feeling, or opinion
      e. provides supporting facts to support positions
   5. expresses ideas and listens to others to solve team problems
   6. works well with team and class members regardless of race class, ethnicity, or religion

C. ***Information:** Acquires and uses information*
   1. acquires and evaluates Information
      a. obtains new or complementary information for various sources such as:
         1) text books
         2) lectures
         3) library
         4) periodicals
         5) internet
      b. evaluates information for accuracy, challenges information that contradicts logical evaluation
   2. keeps and maintains an organized class workbook
   3. gives oral/written presentations to class
   4. uses computers to view drawings

D. ***Systems:** Understands complex inter-relationships*
   1. understands systems
      a. understands systems of drawings
      b. understands function of symbology in drawings
      c. understands the evolution of drawings and drawing symbology
   2. monitors and corrects performance

        - a. evaluates drawings and corrects errors
        - b. uses symbolic drawings to measure components or engineering values
    - 3. finds alternate methods to solve problems
        - a. evaluates alternate components based upon their symbology
        - b. uses symbolic drawings to modify system parameters
- *E. Technology: Works with a variety of technologies*
    - 1. selects technology
        - a. uses the appropriate types of drawings for the system
        - b. understands the use of computer aided design (CAD) in drawings
    - 2. applies drawing technology to the understanding of systems
    - 3. maintains drawing integrity, corrects erroneous drawings

II. FOUNDATION SKILLS

- *A.* ***Basic Skills:*** *Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*
    - **1.** ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
        - a. reads assigned course material
        - b. interprets reading material to perform successfully in class
        - c. interprets graphical data from symbolic drawings
    - **2.** ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
        - a. creates a manufacturing plan from a mechanical drawing
    - **3.** ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
        - a. performs mathematical computations using engineering notation
        - b. applies the principles of plane geometry to mechanical drawings
    - **4.** ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
        - a. actively listens to the information being presented in class and feeds back concepts
        - b. listens to the ideas, feelings, and opinions of fellow classmates
    - *5.* ***Speaking:*** *Organizes ideas and communicates orally*
        - a. presents ideas and information in class
        - b. contributes to classroom discussion.
- *B.* ***Thinking Skills:*** *Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*
    - **1.** ***Creative Thinking:*** *Generates new ideas*
        - a. combines symbols to create systems
        - b. relates symbology to physical objects
    - **2.** ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
        - a. uses drawings to determine manufacturing processes
        - b. applies drawing symbology to determine best course or action for repair of equipment

   3. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
      a. uses drawings to solve problems in physical systems
      b. reads drawing to plan troubleshooting process and method
   4. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
      a. uses drawings to visualize the symbolic relationships of systems
      b. applies engineering data from drawings to perform tests
   5. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
      a. uses effective study techniques to acquire new class material
      b. practices to acquire new skills
   6. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
      a. relates symbols to actual physical objects
      b. applies engineering notation found on drawings to the object symbolized in the drawing

C. ***Personal Qualities:*** *Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*
   1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
      a. performs at or above expected class level
      b. sets individual/group goals and accomplishes them
   2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
      a. contributes to classroom discussion with original ideas
      b. maintains a positive sense of humor that is not at the expense of another person's sense of self worth
   3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
      a. allows divergent views in class discussions
      b. responds positively to new ideas
      c. supports the worthwhile goals and objectives of the team and fellow classmates
   4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
      a. accepts responsibility for completion of assigned work
      b. sets individual/group goals and accomplishes them
      c. maintains a record of accomplishments
   5. ***Integrity/Honesty:*** *Chooses ethical courses of action*
      a. performs own work when required, does not plagiarize the work of others
      b. protects school property
      c. does not misappropriate the property of the school or other classmates
      d. reports infractions of school rules to school authorities

Appropriate Reference Materials:

1. Print Reading for Industry, by Brown, 1995

MAFGI02
05/062896

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

MANUFACTURING PROCESSES

MAST PROGRAM
COURSE SYLLABUS
MANUFACTURING PROCESSES

Lecture hours/week: 3 **Lab hours/week: 3** **Credits: 4**

COURSE DESCRIPTION:

This course is a survey of physical and chemical processes used to manufacture products. This course is designed to provide students who plan to pursue a career in automated manufacturing with the skills that will enable the student to test automated manufacturing processes and to encourage the further pursuit of training in physics and chemistry. The course will explore the principles of physics and chemistry that underlie technologies used to manufacture products in industry; such as machine technology, vacuum technology, heat treating technology, hydraulic and pneumatic technology, and electro-chemical manufacturing processes. The student will employ formulas and the New Metric (S.I.) (mks) system of measurement to solve problems relating to industrial processes. (FT) Associate Degree Credit

PREREQUISITES: **Satisfactory completion with a grade of "C" or better, or concurrent enrollment in, Manufacturing Metrics and Calculations, or equivalent.**

COURSE OBJECTIVES:

Upon successful completion of this course, the student will:

1. Use the rules of mathematics, algebra and trigonometry, and the theories and formulas found in the study of mechanical physics to calculate simple vectored forces
2. Apply the rules of measuring systems in both the English and SI systems of measurement to calculate and convert quantities in both systems
3. Use the rules of mathematics and the theories and formulas found in the study of mechanical physics to understand and calculate the effects on industrial machinery of the following: inertia, force, velocity, momentum, friction, and impulse momentum
4. Use the rules of mathematics and the theories and formulas found in the study of gases and fluids to understand and calculate the effects on industrial machinery of the following properties of matter: Pascal's Law, Charles' and Bolve's Law (Ideal Gas Law), Bernoulli's Principle, pressure, flow, density, specific gravity, evaporation, sublimation, condensation, humidity, and relative humidity
5. Use the rules of mathematics and the theories and formulas found in the study of high pressure and high vacuum systems, to calculate and convert pressures in various pressure systems, including psi (vacuum), psig, psia, inches of water, inches of mercury, bar (absolute), bar (atmospheric), SI system (Pascal's and kilopascals), and the torr system
6. Use the rules of mathematics and the theories and formulas found in the study of thermodynamics to understand, calculate, and convert quantities found in industrial heat treating equipment such as temperature, scales, kilocalories, British Thermal Units,

specific heat, thermal conductivity, expansion and contraction of solids, simple engines, and entropy

7. Use the rules of mathematics and the theories and formulas found in the study of chemistry to calculate the proportions of chemicals used to produce various mixtures
8. Use the rules and procedures found in the concepts of valence, ionization, the periodic table, chemical reaction formulas, and catalysts, to determine the types of elements that are used to obtain a given compound, whether the reaction is a producer of energy or needs energy to occur, and whether or not the reaction needs catalyst to occur
9. Demonstrate the properties of pure water, deionized water, and water with various compounds in solution
10. Perform physical and chemical experiments or tests on actual industrial systems
11. Demonstrate the electro-chemical effect and its usage in batteries, industrial plating, chemical milling, and semi-conductor fabrication
12. Demonstrate the procedures used to deionize water and produce chemically pure water
13. Demonstrate the procedures used in the manufacture of industrial chemicals

REQUIRED COURSE MATERIALS:

Textbook: An example of typical text for this course would be Physics for Career Education, by Ewen/Nelson/Schurter, 1993, and Chemistry Principles and Reactions, by Masterton/Hurley, 1991

Lab Materials: Students will be required to purchase the following supplies:

1) Paper, notebooks, Compass, protractor, ruler
2) Protective lab apron, safety glasses
3) Scientific calculator, Scantron examination sheets

METHODS OF INSTRUCTION:

Lecture: Presentations will include lecture, video, and group problem solving.

Laboratory: Laboratory will be "hands-on" measurements of physical and chemical manufacturing processes.

Group Projects Group lab projects will be assigned during the lab periods. Each set of projects will provide practice in one of the manufacturing processes. The students will work on problems that are derived from manufacturing or industrial situations. Homework will be research of the problem. The individual grade for these tasks will be a combination of a team grade, and a team assessment of the individual's contribution to the team's efforts. The instructor will devise a method whereby the team's assessment of an individual's contributions is fair and free of bias.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. perform on written or oral examinations
2. perform on outside assignments

3. contribute to group problem solving
4. apply theory to problem solving
5. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Machine Technology		
A. Rules of mechanics		
B. Work power and energy		
C. Simple machines		
D. Complex machines		
E. Rotational forces		
Thermal Technology		
A. Materials		
B. Heat energy		
C. Heat transfer		
D. Thermodynamics		
Hydraulic and Pneumatic Technology		
A. Force, pressure and flow		
B. Measuring scales		
C. Ventori		
D. Laws of fluid dynamics		
Atomic Structure		
A. Valance		
B. Elements		
C. The periodic table		
D. Mixtures		
E. Compounds		
F. Mixing formulas		
Chemical Formulas		
A. Endothermic and exothermic reactions		
B. Catalysts		
C. Electrochemistry		
D. Water, the universal solvent		
E. Material safety data sheets (OSHA)		
Vacuum Technology		
A. Behavior of gasses		
B. Nature of vacuum		
C. Vacuum pumping system		
D. Vacuum instrumentation		
	Total Lecture Hours	—

LAB OUTLINE:

Lab Topic	Text Reference Page	Contact Hrs.
Construct and Measure Simple Machines		

A. Levers
B. Gears
C. Ramps
D. Pulleys
E. Rotational Machines (Bicycle)

Analyze and Measure a Complex Machine Such as a Mill or Lathe Axis

A. Identify Simple Machines
B. Create a Theoretical Model of Complex Machine
C. Measure Machine
D. Analyze Results

Heat Treating

A. Test and Measure Thermocouples
B. Test and Measure Resistance Temperature Devices (RTD)
C. Create Theoretical Model of Heat Treating Oven
D. Solve Mathematical Problems in Model

Hydraulic and Pneumatic Technology

A. Construct and Measure Hydraulic Circuits
B. Construct and Measure Pneumatic Circuits
C. Construct and Measure Ventori

Vacuum Technology

A. Construct Vacuum Circuits and Measure Properties
B. Practice Safe Procedures for High Vacuum Equipment
C. Use High Vacuum Measurement Equipment

Chemical Technology

A. Measure Electrical Properties of Distilled Water
B. Measure Electrical Properties of Tap Water
C. Apply Mixing Formulas to Create Solutions and Mixtures
D. Measure Electrical Properties of Distilled Water With Measured Amounts of Acids and Bases
E. Create Chemical Reactions and Measure Results

Total Lecture Hours ___

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

Upon successful completion of this course the student will be able to:

A. **USE THE RULES OF MATHEMATICS, ALGEBRA AND TRIGONOMETRY, AND THE THEORIES AND FORMULAS FOUND IN THE STUDY OF MECHANICAL PHYSICS, TO CALCULATE SIMPLE VECTORED FORCES**
    1. Apply the Concept of Scalar and Vector Quantities to Measurement of Physical Systems
        a. Mechanical systems, machines
        b. Thermal systems, furnaces
        c. Pressure systems, hydraulic, pneumatic, vacuum
    2. Determine Vectors and Set up a Diagram of Vectored Forces
    3. Calculate the Resultant of Simple Vectored Forces Using Trigonometry

B. **APPLY THE RULES OF MEASURING SYSTEMS IN BOTH THE ENGLISH AND SI SYSTEMS OF MEASUREMENT, TO CALCULATE AND CONVERT QUANTITIES IN BOTH SYSTEMS**
    1. Understand the Basic Units of Measurement in the English Engineering Systems of Measurement
        a. Mass
        b. Force
        c. Length
        d. Volume
        e. Time
        f. Temperature
    2. Understand the Basic Units of Measurement in the Metric (International, mks) (S.I.) Systems of Measurement
        a. Mass
        b. Force
        c. Length
        d. Volume
        e. Time
        f. Temperature
    3. Calculate Quantities Derived from the Basic Units of Both Systems (Dimensions)
    4. Convert Basic and Dimensional Quantities from the English Engineering System to the Metric (S.I.) System and Vise-Versa

C. **USE THE RULES OF MATHEMATICS, AND THE THEORIES AND FORMULAS FOUND IN THE STUDY OF MECHANICAL PHYSICS, TO UNDERSTAND AND CALCULATE THE EFFECTS ON INDUSTRIAL MACHINERY OF THE FOLLOWING; INERTIA, FORCE, VELOCITY, MOMENTUM, FRICTION, AND IMPULSE MOMENTUM**
    1. Apply the Formulas Used to Determine the Dimensions for Basic Physical Measurements
        a. Mass-slugs, kilograms
        b. Force-pounds, newtons
        c. Work-energy, foot-pounds, joules
        d. Power-horsepower, watts
        e. Torque-foot-pounds, newton-meters
        f. Momentum, impulse momentum

g. Friction

2. Calculate and Measure the Effects of the above Physical Quantities upon Industrial Machines Such as Lathes, Mills, Presses, or Other Types of Moving Machinery

D. USE THE RULES, FORMULAS AND PROCEDURES FOUND IN THE STUDY OF MECHANICAL SYSTEMS TO IDENTIFY SIMPLE MACHINES FOUND IN COMPLEX MACHINES, CALCULATE THE MECHANICAL ADVANTAGES THESE MACHINES, AND APPLY THE PRINCIPLES OF FORCE, WORK, POWER, MOMENTUM, IMPULSE MOMENTUM, AND FRICTION TO CALCULATE AND MEASURE THE RESULT OF THESE FORCES UPON THE COMPLEX MACHINE

1. Identify Simple Machines Such As:
   a. Levers
   b. Ramps
   c. Screws
2. Calculate the Total Effects upon the Complex Machine of the Individual Mechanical Advantages of the Simple Machines
3. Apply the Effects of Physical Dimensions to Calculate the Behavior of the System
   a. Mass-slugs, kilograms
   b. Force-pounds, newtons
   c. Work-energy, foot-pounds, joules
   d. Power-horsepower, watts
   e. Momentum, impulse momentum
   f. Friction
4. Measure the Effects of the above Simple Machines upon Industrial Equipment Such as Lathes, Mills, Presses, or Other Types of Complex Machinery

E. USE THE RULES, FORMULAS AND PROCEDURES FOUND IN THE STUDY OF MECHANICAL SYSTEMS TO IDENTIFY ROTATIONAL MACHINES FOUND IN COMPLEX MACHINES, SUCH AS GEAR TRAINS, PULLEYS, AND WHEEL AND AXLE SYSTEMS; CALCULATE THE MECHANICAL ADVANTAGES OF THESE MACHINES, AND APPLY THE PRINCIPLES OF FORCE, WORK, POWER, MOMENTUM, IMPULSE MOMENTUM, AND FRICTION TO CALCULATE AND MEASURE THE RESULTS OF THESE FORCES UPON THE COMPLEX MACHINE

1. Identify Rotational Machines Such As:
   a. Wheel and axle
   b. Pulleys
   c. Gear trains
2. Calculate the Total Effects upon the Complex Machine of the Individual Mechanical Advantages of the Rotational Machines
3. Apply the Effects of Physical Dimensions to Calculate the Behavior of the System
   a. Mass-slugs, kilograms
   b. Rotational power-horsepower, watts
   c. Torque-foot-pounds, newton-meters
   d. Angular momentum, impulse momentum
   e. Friction
4. Measure the Effects of the above Simple Rotational Machines upon Industrial Equipment Such as Lathes, Mills, Presses, or Other Types of Rotating Machinery

F. USE THE RULES OF MATHEMATICS, AND THE THEORIES AND FORMULAS FOUND IN THE STUDY OF GASES AND FLUIDS, TO UNDERSTAND AND CALCULATE THE EFFECTS ON INDUSTRIAL MACHINERY OF THE FOLLOWING PROPERTIES OF MATTER: PASCAL'S LAW, CHARLES' AND BOYLE'S LAW (IDEAL GAS LAW), BERNOULLI'S PRINCIPLE, PRESSURE, FLOW, DENSITY, SPECIFIC GRAVITY, EVAPORATION, SUBLIMATION, CONDENSATION, HUMIDITY, AND RELATIVE HUMIDITY

1. Explain the Principles of the Following:
    - a. Pascal's Law
    - b. Ideal Gas Laws
    - c. Borneol's Principle
    - d. Pressure
    - e. Flow
    - f. Density
    - g. Specific gravity
    - h. Evaporation
    - i. Sublimation
    - j. Condensation
    - k. Humidity
2. Apply the Formulas for the Following to Calculate the Effects of Each Concept on Industrial Machinery
    - a. Pressure
    - b. Density
    - c. Specific gravity
    - d. Pressure and force created by pressure
    - e. Relative humidity
3. Measure the above Quantities on Industrial Equipment Such As:
    - a. Mechanical systems
    - b. Heat treating systems
    - c. Pneumatic systems
    - d. Vacuum systems
    - e. Hydraulic systems

G. USE THE RULES OF MATHEMATICS, AND THE THEORIES AND FORMULAS FOUND IN THE STUDY OF HIGH PRESSURE AND HIGH VACUUM SYSTEMS, TO CALCULATE AND CONVERT PRESSURES IN VARIOUS PRESSURE SYSTEMS INCLUDING PSI (VACUUM), PSIG, PSIA, INCHES OF WATER, INCHES OF MERCURY, BAR (ABSOLUTE), BAR (ATMOSPHERIC), SI SYSTEM (PASCAL'S AND KILOPASCALS), AND THE TORR SYSTEM

1. Explain the Formulas, Dimensions, and Principles of the Following:
    - a. Force pressure scales English engineering system
        - 1) Pounds per square inch absolute (PSIA)
        - 2) Pounds per square inch gauge (PSIG)
    - b. Force pressure scales metric mks system
        - 1) Newtons pre square meter absolute (pascals)(pa)
        - 2) Kilo newtons per square meter absolute (kpaA)
        - 3) Kilo newtons per square meter gauge (kpaG)

        - c. Atmospheric pressure scales
            - 1) Pressure of atmosphere
            - 2) Bar (gauge)
            - 3) Millibar (absolute)
        - d. Length pressure scales
            - 1) Inches of mercury (in Hg)
            - 2) Millimeters of mercury (mm Hg)
            - 3) Inches of water (in H_2O)
        - e. Vacuum pressure scales
            - 1) Pounds per square inch vacuum (PSIV)
            - 2) Microns
            - 3) Torr
    - 2. Convert Pressures from One Pressure Scale to Another

H. USE THE RULES OF MATHEMATICS, AND THE THEORIES AND FORMULAS FOUND IN THE STUDY OF THERMODYNAMICS, TO UNDERSTAND, CALCULATE, AND CONVERT QUANTITIES FOUND IN INDUSTRIAL HEAT TREATING EQUIPMENT SUCH AS; TEMPERATURE SCALES, KILOCALORIES, BRITISH THERMAL UNITS, SPECIFIC HEAT, THERMAL CONDUCTIVITY, EXPANSION AND CONTRACTION OF SOLIDS, SIMPLE ENGINES, AND ENTROPY

- 1. Explain the Concept of Temperature and Temperature Scales
    - a. Degrees Fahrenheit
    - b. Degrees Celsius
- 2. Convert Temperatures from One Temperature Scale to Another
- 3. Explain the Concept and Dimensions of Heat and Heat Measurement
    - a. British Thermal Unit (BTU)
    - b. Kilocalorie (Kcal)
- 4. Convert Heat Quantities
    - a. BTU to Kcal and vice versa
    - b. Heat to energy:
        - 1) Joules
        - 2) Foot-pounds
        - 3) Kilowatt-hours
- 5. Apply the Concept of Specific Heat to Determine the Amount of Heat Needed to Satisfy the Requirements of Materials Such as Steel, Air, Carbon, Etc.
    - a. Determine the amount of heat needed to raise a specified atmospheric furnace to a specified temperature
    - b. Determine the amount of heat needed to raise a quantity of steel, aluminum, or carbon to a specific temperature
- 6. Explain the Concept of Thermal Expansion
- 7. Apply the Concept of Simple Heat Engines to the Understanding Of:
    - a. Air conditioners
    - b. Internal combustion engines
    - c. External combustion engines
- 8. Apply the Concept of Entropy to the Understanding Of:
    - a. Electrical power distribution systems
    - b. Hydraulic and pneumatic power distribution

I. **USE THE RULES OF MATHEMATICS, AND THE THEORIES AND FORMULAS FOUND IN THE STUDY OF CHEMISTRY, TO CALCULATE THE PROPORTIONS OF CHEMICALS USED TO PRODUCE VARIOUS MIXTURES**
  1. Apply Mixing Formulas and the Molar Concept of Chemistry to Determine the Quantities of Elements Need to Produce a Molar Reaction
  2. Apply Mixing Formulas to Produce Proportions of Various Mixes, Solutions, and Compounds

J. **USE THE RULES AND PROCEDURES FOUND IN THE CONCEPTS OF VALENCE, IONIZATION, THE PERIODIC TABLE, CHEMICAL REACTION FORMULAS, AND CATALYSTS, TO DETERMINE THE TYPES OF ELEMENTS THAT ARE USED TO OBTAIN A GIVEN COMPOUND, WHETHER THE REACTION IS A PRODUCER OF ENERGY OR NEEDS ENERGY TO OCCUR, AND WHETHER OR NOT THE REACTION NEEDS A CATALYST TO OCCUR**
  1. Use the Periodic Table to Identify Elements
  2. Use the Periodic Table to Calculate Molar Quantities
  3. Apply the Concept of Ionization or Valence and the Periodic Table to Determine Reactions
  4. Apply Reaction Formulas to Determine the Following:
     a. Number and type of elements
     b. Energy release or energy needed
     c. Catalyst needed
  5. Explain the Procedures Used to Determine the Make-up of Compounds

K. **DEMONSTRATE THE PROPERTIES OF PURE WATER, DE-IONIZED WATER, AND WATER WITH VARIOUS COMPOUNDS IN SOLUTION**
  1. Demonstrate the Resistive Properties of Chemically Pure Water and Ionized Water
  2. Explain the Concept of Ph in Terms of Hydroxyl and Hydrogen Ions
  3. Apply the Concept of Ionization and Ph to Determine If Water Is Ionized with a Acid or a Base

L. **PERFORM PHYSICAL AND CHEMICAL EXPERIMENTS OR TESTS ON ACTUAL INDUSTRIAL SYSTEMS**
  1. Explain the Uses of Bases or Acids in Manufacturing Processes
  2. Perform Physical and Chemical Tests on Lead Acid Batteries
  3. Perform Physical and Chemical Tests on Electro-plating Solutions
  4. Perform Physical and Chemical Test on Chemical Milling Solutions

M. **DEMONSTRATE THE ELECTRO-CHEMICAL EFFECT AND ITS USAGE IN BATTERIES, INDUSTRIAL PLATING, CHEMICAL MILLING, AND SEMI-CONDUCTOR FABRICATION**
  1. Demonstrate the Electro-chemical Effect in Lead Acid Batteries
  2. Demonstrate the Electro-chemical Effect in Electro-plating Solutions
  3. Demonstrate the Electro-chemical Effect in Ion Implantation and Photo-etching of Semiconductor Wafers

N. **DEMONSTRATE THE PROCEDURES USED TO DE-IONIZE WATER AND PRODUCE CHEMICALLY PURE WATER**
  1. Demonstrate the Reverse Osmosis Method of Water Filtration and Explain the Processes
  2. Demonstrate De-ionization Techniques and Explain the Reaction
  3. Explain the Procedures Used to Monitor and Protect Pure Water Systems

O. DEMONSTRATE TYPICAL SAFETY PROCEDURES USED IN THE MANUFACTURE OF INDUSTRIAL CHEMICALS

1. Handle Chemicals Properly
    a. Interpret material safety data sheets (MSDS)
    b. Explain hazards of industrial chemicals
    c. Properly dispose of used chemicals
2. Identify Fire Hazards for Industrial Chemicals
    a. Identify flammable chemicals
    b. Identify types and uses of, chemical fire extinguishers
3. Explain Proper Personal Hygiene When Dealing with Industrial Chemicals
    a. Explain effects of acids and bases on skin and eyes
    b. Explain emergency procedures used to wash chemicals from eyes and skin

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. Resources: *Identifies, organizes, plans, and allocates resources*

1. allocates time
    a. completes assigned work on time
    b. successfully completes timed examinations

B. Interpersonal: Works with others

1. participates as a member of a team
    a. participates in team lab
    b. participates in study groups
2. teaches others
    a. helps team members solve problems
    b. contributes information to teams/study groups
3. satisfies instructor assigned requirements
4. exercises leadership
    a. forms study groups
    b. motivates teams/study groups to succeed
    c. expresses ideas, feelings, and opinions clearly
    d. identifies whether the source of a position is an idea, feeling, or opinion
    e. provides supporting facts to support positions
5. expresses ideas and listens to others to solve team problems

        6. works well with team and class members regardless of race class, ethnicity, or religion

C. ***Information:** Acquires and uses information*
  1. acquires and evaluates Information
    - a. obtains new or complementary information for various sources such as:
      - 1) text books
      - 2) lectures
      - 3) library
      - 4) periodicals
      - 5) internet
    - b. evaluates information for accuracy, challenges information that contradicts logical evaluation
  2. keeps and maintains an organized class lab workbook
  3. gives oral/written presentations to class

D. ***Systems:** Understands complex inter-relationships*
  1. understands systems
    - a. understands complex physical systems
    - b. understands the connections between physics and chemistry and their role in industrial systems
  2. monitors and corrects performance
    - a. tests systems to determine if they are meeting theoretical expectations
    - b. corrects systems or theory from results of evaluation
  3. finds alternate methods to test industrial systems

E. ***Technology:** Works with a variety of technologies*
  1. selects appropriate technology to perform physical or chemical measurements
  2. applies technology to the tests/measurements
  3. troubleshoots industrial systems and processes

II. FOUNDATION SKILLS

A. ***Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*
  1. ***Reading:** Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
    - a. reads assigned course material
    - b. interprets reading material to perform successfully in class
    - c. interprets laboratory data/graphs

  2. ***Writing:** Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    - a. creates lab reports from laboratory data
    - b. writes report/term paper on industrial systems

  3. ***Arithmetic/Mathematics:** Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*

        a. performs mathematical computations using scientific notation and engineering notation
        b. applies the principles of algebra, geometry, and trigonometry to solve technical problems
    4. ***Listening:** Receives, attends to, interprets, and responds to verbal messages and other cues*
        a. actively listens to the information being presented in class and feeds back concepts
        b. listens to the ideas, feelings, and opinions of fellow classmates
    5. ***Speaking:** Organizes ideas and communicates orally*
        a. presents ideas and information in class
        b. contributes to classroom discussion.

B. ***Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*
    1. ***Creative Thinking:** Generates new ideas*
        a. combines the principles of physics and chemistry to the understanding of complex manufacturing processes
        b. applies math, physics, and chemistry to the analysis of complex industrial equipment such as heat treating furnaces, water treatment systems, high vacuum systems
    2. ***Decision Making:** Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
        a. uses formulas and mathematics to predict the limits of behavior of industrial systems
        b. uses formulas and mathematics to determine alternate/desirable changes in industrial systems
    3. ***Problem Solving:** Recognizes problems and devises and implements plan of action*
        a. uses mathematics, physics, and chemistry to solve problems in industrial systems
        b. chooses desired course of action based upon results of analysis
    4. ***Seeing Things In the Mind's Eye:** Organizes, and processes symbols, pictures, graphs, objects, and other information*
        a. uses scientific principles, symbolic diagrams, and mathematics to visualize the complex interrelationships of parts of industrial systems
    5. ***Knowing How to Learn:** Use efficient learning techniques to acquire and apply new knowledge and skills*
        a. uses effective study techniques to acquire new class material
        b. practices to acquire new skills
    6. ***Reasoning:** Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
        a. applies the principles of mechanical physics to the understanding of the behavior of an industrial machine
        b. applies the concept of entropy to the understanding of power transmission systems, and heat engines
        c. understands the relationship between power and heat

C. ***Personal Qualities:*** *Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    a. performs at or above expected class level
    b. sets individual/group goals and accomplishes them
2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    a. contributes to classroom discussion with original ideas
    b. maintains a positive sense of humor that is not at the expense of another person's sense of self worth
3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. allows divergent views in class discussions
    b. responds positively to new ideas
    c. supports the worthwhile goals and objectives of the team and fellow classmates
4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. accepts responsibility for completion of assigned work
    b. sets individual/group goals and accomplishes them
    c. maintains a record of accomplishments
5. ***Integrity/Honesty:*** *Chooses ethical courses of action*
    a. performs own work when required, does not plagiarize the work of others
    b. protects school property
    c. does not misappropriate the property of the school or other classmates
    d. reports infractions of school rules to school authorities

Appropriate Reference Materials:

1. Technical Physics by Erwin/Selleck, 1991
2. The Sciences, An Integrated Approach by Trefil/Hazen, 1995

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program
MAST

COURSE SYLLABUS

INDUSTRIAL PROGRAMMING THEORY

MAST PROGRAM
COURSE SYLLABUS
INDUSTRIAL PROGRAMMING THEORY

Lecture hours/week: 2 **Lab hours/week: 3** **Credit hours: 3**

COURSE DESCRIPTION:

This course covers the basic digital mathematical concepts required for effective performance as an automation technician or machine technologist in the computerized machine tool industry. This course will include examples taken from computers or microprocessor systems that are typically found in the modern industrial manufacturing facility, such as industrial computers, programmable logic controllers, and microprocessor based control systems. (FT) Associate Degree Credit

PREREQUISITES: **Satisfactory completion with a grade of "C" or better, or concurrent enrollment in, Manufacturing Metrics and Calculations, or equivalent**

COURSE OBJECTIVES:

Upon successful completion of this course, the student will be able to:

1. Use the mathematics of numbering systems to create new numbering systems and convert mathematical quantities in numbering systems such as decimal, binary, octal, and hexadecimal from one numbering system to another
2. Use quantities from the binary numbering system to perform mathematical operations on these quantities, such as addition, subtraction, multiplication, and division
3. Use Boolean algebra to express a complex logic problem in Boolean expressions and apply this knowledge to the solution of programming problems
4. Identify the major software components of a computer microprocessor control system, such as the Disk Operating System (DOS), Graphic User Interface (GUI), or Basic Input-Output System (BIOS), and explain the function of each system
5. Use a personal computer to accomplish tasks such as formatting a disk, creating and using files, copying disks and files, configuring a serial or parallel computer interface, and configuring add-on modules
6. Use a personal computer to connect communications cables to the computers communications ports such as RS-232, RS-485, and Local Area Network (LAN) cables
7. Use a programming language such as BASIC or statement list programming to program a control task

REQUIRED COURSE MATERIALS:

Textbook: An example of an appropriate text would be Introducing Computers-Concepts, Systems, and Applications by Blissmer, 1995-1996

Lab Materials: Students will be required to purchase the following supplies:

1) Paper, notebooks and writing instruments
2) Safety glasses
3) Scientific calculator, Scantron examination sheets

METHODS OF INSTRUCTION:

Lecture: Presentations will include lecture, demonstration, and group problem solving.

Group Projects: Group projects will be assigned during the lab periods. Each set of projects will provide practice in one or more concepts. The students will work on problems that are derived from manufacturing or industrial situations. Any problems not solved by the team will be assigned as homework problems. The individual grade for these tasks will be a combination of a team grade, and a team assessment of the individual's contribution to the team's efforts. The instructor will devise a method whereby the team's assessment of an individual's contributions is fair and free of bias.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. perform on written or oral examinations
2. perform on outside assignments
3. contribute to group problem solving
4. apply theory to problem solving
5. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Numbering Systems		
A. Theory of numbering systems		
B. Practice in creating numbering systems		
C. The Binary numbering system		
D. The octal numbering system		
E. The hexadecimal numbering system		
F. Numbering system conversions		
G. Mathematical operations in the binary numbering system (addition, subtraction, multiplication and division)		
Boolean Algebra		
A. Boolean operators (and, or, inclusive or, exclusive or, negation)		

B. Truth tables
C. Complex logic expressions (combinational logic)
D. Boolean theorems and operations (Demorgan's Theory, etc.)
E. Symbolic logic (gate symbols, etc.)
F. Conversions from Boolean expressions to symbolic logic
G. Conversions from Boolean expressions to ladder logic

Elements of a Computer System

A. Hardware
B. Software
C. Operating system

Programming

A. Programming concepts
B. Structured programming —

Total Lecture Hours

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

Upon successful completion of this course the student will be able to:

A. USE THE MATHEMATICS OF NUMBERING SYSTEMS TO CREATE NEW NUMBERING SYSTEMS, AND CONVERT MATHEMATICAL QUANTITIES IN NUMBERING SYSTEMS SUCH AS DECIMAL, BINARY, OCTAL, AND HEXADECIMAL, FROM ONE NUMBERING SYSTEM TO ANOTHER

1. Explain the Rules Used to Create Numbering Systems
2. Recite the Powers of 2 from 2 to the Zero Power to 2 to the Sixteenth Power
3. Count from One to 20 in Binary, Octal, and Hexadecimal
4. Freely Convert Numbers from One Base to Another in the Following Number Systems
    a. Binary
    b. Octal
    c. Hexadecimal
    d. Decimal

B. USE QUANTITIES FROM THE BINARY NUMBERING SYSTEM AND PERFORM MATHEMATICAL OPERATIONS ON THESE QUANTITIES SUCH AS ADDITION, SUBTRACTION, MULTIPLICATION, AND DIVISION

1. Add Binary Numbers
2. Perform Twos Complement Addition (Algebraic Subtraction)
3. Multiply Binary Numbers
4. Divide Binary Numbers

C. USE BOOLEAN ALGEBRA TO EXPRESS A COMPLEX LOGIC PROBLEM IN BOOLEAN EXPRESSIONS, AND APPLY THIS KNOWLEDGE TO THE SOLUTION OF PROGRAMMING PROBLEMS

1. Express a Complex Logic Problem in Boolean Algebra Statements
2. Program a Personal Computer to Perform the above Logic Function, Using Any Programming Language

D. IDENTIFY THE MAJOR SOFTWARE COMPONENTS OF A COMPUTER MICROPROCESSOR CONTROL SYSTEM, SUCH AS THE DISK OPERATING SYSTEM (DOS), GRAPHIC USER INTERFACE (GUI), OR BASIC INPUT-OUTPUT SYSTEM (BIOS), AND EXPLAIN THE FUNCTION OF EACH SYSTEM

1. Identify the Functions of the Disk Operating System
    - a. Explain the concept of a file
    - b. Manipulate files
    - c. Explain the concept of a directory
    - d. Create a directory tree
    - e. Explain the concept of a port
    - f. Operate the input/output ports of the computer
2. Explain the Functions of the Basic Input/output System (BIOS) in Terms of the above Tasks
3. Identify the Function of a Graphic User Interface in Term of the above Functions

E. IDENTIFY THE MAJOR HARDWARE COMPONENTS OF A COMPUTER MICROPROCESSOR CONTROL SYSTEM, SUCH AS THE MICROPROCESSOR, MOTHER BOARD, MEMORY, DISK CONTROL MODULE, VIDEO MODULE, I/O PORT MODULE, MODEM, AND NETWORK MODULE, AND EXPLAIN THE FUNCTION OF EACH SYSTEM

1. Identify the Different Classes of Microprocessor for Two Types of Personal Computers
2. Explain the Purpose of the Microprocessor
3. Identify, and Explain the Function of the Mother Board of a Personal Computer
4. Identify, and Explain the Function of the Memory of a Personal Computer
5. Identify, and Explain the Function of the Disk Control Module of a Personal Computer
6. Identify, and Explain the Function of the Video Module of a Personal Computer
7. Identify, and Explain the Function of the I/O Port Module of a Personal Computer
8. Identify, and Explain the Function of the Modem Module of a Personal Computer
9. Identify, and Explain the Function of the Network Module of a Personal Computer

F. USE A PERSONAL COMPUTER TO ACCOMPLISH TASKS SUCH AS; FORMATTING A DISK, CREATING AND USING FILES, COPYING DISKS AND FILES, CONFIGURING A SERIAL OR PARALLEL COMPUTER INTERFACE, AND CONFIGURING ADD-ON MODULES

1. Format a Disk for Use in the Computer
2. Create a Directory Structure on the Disk
3. Manipulate Files on the Disk
    - a. Copy files
    - b. Delete files
    - c. View files
    - d. Append files
4. Configure a Parallel Port
5. Configure a Serial Port
6. Install and Configure Add-on Modules Such as Network Cards

G. USE A PERSONAL COMPUTER, TO CONNECT COMMUNICATIONS CABLES TO THE COMPUTERS COMMUNICATIONS PORTS SUCH AS RS-232, RS-422, AND LOCAL AREA NETWORK (LAN) CABLES

1. Install Coaxial Cables from One Computer to Another in a Network System
2. Install Serial Cable for Communication from a Computer to a Robot, PLC, or CNC Machine
3. Configure the Communications Interface and Make it Function Properly

H. USE A PROGRAMMING LANGUAGE SUCH AS BASIC OR STATEMENT LIST PROGRAMMING TO PROGRAM A CONTROL TASK

1. Explain the Proper Procedures to Accomplish Structured Programming
2. Draw a Flow Chart or Programming Plan
3. Comment the Program Properly
4. Program a Control Task

I. APPLY DIGITAL ELECTRONIC MEASUREMENT KNOWLEDGE AND INSTRUMENTS TO TEST COMMUNICATIONS PORTS

1. Use Digital Multimeters to Test Power Supplies
2. Use Serial Port Testers to Test RS-232 Ports
3. Explain the Methods Used to Test Local Area Network Ports

J. SAFELY ASSEMBLE OR DISASSEMBLE INDUSTRIAL COMPUTERS

1. Completely Disassemble a Personal Computer
2. Re-assemble a Personal Computer, Configure It, and Make it Functional
3. Explain the Proper Procedures Used for Handling Printed Circuit Boards
4. Demonstrate the Safety Procedures Used When Tearing down a PC

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

- *A.* ***Resources:*** *Identifies, organizes, plans, and allocates resources*
  1. allocates time
     a. completes assigned work on time
     b. successfully completes timed examinations
- *B.* ***Interpersonal:*** *Works with others*
  1. participates as a member of a team
     a. participates in team problem solving
     b. participates in study groups
  2. teaches others

        - a. helps team members solve problems
        - b. contributes information to teams/study groups
    - 3. satisfies instructor assigned requirements
    - 4. exercises leadership
        - a. forms study groups
        - b. motivates teams/study groups to succeed
        - c. expresses ideas, feelings, and opinions clearly
        - d. identifies whether the source of a position is an idea, feeling, or opinion
        - e. provides supporting facts to support positions
    - 5. expresses ideas and listens to others to solve team problems
    - 6. works well with team and class members regardless of race class, ethnicity, or religion
- C. *Information: Acquires and uses information*
    - 1. acquires and evaluates Information
        - a. obtains new or complementary information for various sources such as:
            - 1) text books
            - 2) lectures
            - 3) library
            - 4) periodicals
            - 5) internet
        - b. evaluates information for accuracy, challenges information that contradicts logical evaluation
    - 2. keeps and maintains an organized class lab workbook
    - 3. gives oral/written presentations to class
    - 4. uses computers to program control concepts
- *D.* *Systems: Understands complex inter-relationships*
    - 1. understands systems
        - a. understands systems of numbers
        - b. understands functions of computer systems
    - 2. finds alternate methods to solve programming problems
- *E.* *Technology: Works with a variety of technologies*
    - 1. selects technology
        - a. applies the appropriate programming tools to solve problems
        - b. understands the use of computers to control machines
    - 2. applies programming/computers to task
    - 3. if program/computer does not perform as expected, finds problem

II. FOUNDATION SKILLS

- *A.* ***Basic Skills:*** *Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*
    - **1.** ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
        - a. reads assigned course material
        - b. interprets reading material to perform successfully in class

2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    a. documents programs
3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    a. performs mathematical computations using binary mathematics
    b. performs symbolic mathematical operations using Boolean algebra
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
    a. actively listens to the information being presented in class and feeds back concepts
    b. listens to the ideas, feelings, and opinions of fellow classmates
5. ***Speaking:*** *Organizes ideas and communicates orally*
    a. presents ideas and information in class
    b. contributes to classroom discussion.

B. ***Thinking Skills:*** *Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. ***Creative Thinking:*** *Generates new ideas*
    a. uses computers and programming concepts to create machine control solutions
2. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. uses proper structured programming concepts
3. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    a. uses appropriate programming techniques/mathematics to solve programming problems
    b. chooses proper methods to set up computers
4. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. plans program steps, processes flow chart symbols
5. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. uses effective study techniques to acquire new class material
    b. practices to acquire new skills
6. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. relates concepts of computer operations and control of machines/processes

C. ***Personal Qualities:*** *Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    a. performs at or above expected class level
    b. sets individual/group goals and accomplishes them

2. ***Self-Esteem:** Believes in own self-worth and maintains a positive view of self*
    a. contributes to classroom discussion with original ideas
    b. maintains a positive sense of humor that is not at the expense of another person's sense of self worth
3. ***Sociability:** Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. allows divergent views in class discussions
    b. responds positively to new ideas
    c. supports the worthwhile goals and objectives of the team and fellow classmates
4. ***Self-Management:** Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. accepts responsibility for completion of assigned work
    b. sets individual/group goals and accomplishes them
    c. maintains a record of accomplishments
5. ***Integrity/Honesty:** Chooses ethical courses of action*
    a. performs own work when required, does not plagiarize the work of others
    b. protects school property
    c. does not misappropriate the property of the school or other classmates
    d. reports infractions of school rules to school authorities

Appropriate Reference Materials:

1. Industrial Computing, Pub. of Instrument Society of America (ISA)

MAFGI11
05/062896

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

INDUSTRIAL ELECTRONICS/ELECTRICITY

MAST PROGRAM
COURSE SYLLABUS
INDUSTRIAL ELECTRONICS/ELECTRICITY

Lecture hours/week: 2 **Lab hours/week: 6** **Credit hours: 4**

COURSE DESCRIPTION:

Through the use of hands-on experimentation and classroom lectures, the principles of operation of common electronics/electrical components are introduced. This course includes Ohm's Law, component testing, and the use of test equipment. It also includes the theory of operation of various components such as switches, relays, transformers, motors, sensors, and diodes. (FT) Associate Degree Credit

PREREQUISITES: **Satisfactory completion with a grade of "C" or better, or concurrent enrollment in Manufacturing Metrics and Calculations, Print Reading and Symbology, or equivalent**

COURSE OBJECTIVES:

Upon successful completion of this course, the student will:

1. Apply mathematical formulas and the rules of mathematics to calculate and predict the behavior of the following quantities in DC electronics/electricity, resistance, voltage, current, power, and capacitor-resistor time constants
2. Apply mathematical formulas and the rules of mathematics to calculate and predict the behavior of the following quantities in AC electronics/electricity, resistance, voltage, current, power, inductive reactance, capacitive reactance, peak AC voltage and current, peak-to-peak AC voltage and current, RMS, and average AC voltage and current
3. Use mathematical formulas and the rules of mathematics from the study of algebra, basic vector mathematics, and trigonometry to calculate and predict the behavior of the following quantities in AC electronics/electricity, impedance of series resistive-capacitive circuits, impedance of series inductive-resistive circuits, and phase angle in the above circuits
4. Apply the rules of AC electronics/electricity to predict and measure the voltage, current and phase angle in three phase AC circuits
5. Properly set up, calibrate, and use meters, function generators, and oscilloscopes to accurately test resistance, voltage, current, frequency, and time in both DC and AC circuits
6. Use components such as resistors, inductors, and capacitors to construct circuits and test the components in both DC and AC circuits to determine if the components are operating properly
7. Use oscilloscopes, meters and the metrology of electrical measurement to measure phase shift and phase angle in series resistive-capacitive and series resistive-inductive AC circuits
8. Apply the theory of electro-magnetism to explain the operation of magnetically coupled devices such as relays, solenoids, transformers, and electrical motors

9. Use meters function generators and oscilloscopes to test magnetically coupled devices such as relays, solenoids, transformers, and electrical motors to determine if they are operating properly
10. Identify DC motors such as permanent magnetic DC motors, series field DC motors, shunt field DC motors, combination DC motors, and universal motors
11. Identify AC motors such as split phase capacitive start motors, split phase capacitive start-capacitive run motors, inductive start-inductive run motors, three phase squirrel cage motors, and universal motors
12. Use the rules of semiconductor diodes such as barrier potential, PIV, forward bias, and reverse bias to test front-to-back ratios and measure forward and reverse voltage drop

REQUIRED COURSE MATERIALS:

Textbook: An example of a Text which would be appropriate for this course is: Electricity/Electronics Fundamentals by Zbar/Sloop 4th Edition, 1992 and Introductory DC/AC Electronics by Nigel P. Cook 2nd Edition, 1992 (with interactive software)

Lab Materials: Students will be required to purchase the following supplies:
1) Paper, notebooks and writing instruments
2) Safety glasses
3) Scientific calculator, Scantron examination sheets

METHODS OF INSTRUCTION:

Lecture: Presentations will include lecture, demonstration, group problem solving

Laboratory: Laboratory will be a "hands-on" Electrical/Electronic labs

Group Projects: Group projects will be assigned during the lab periods. Each set of projects will provide practice in one or more concepts. The students will work on problems that are derived from manufacturing or industrial situations. Any problems not solved by the team will be assigned as homework problems. The individual grade for these tasks will be a combination of a team grade, and a team assessment of the individual's contribution to the team's efforts. The instructor will devise a method whereby the team's assessment of an individual's contributions is fair and free of bias.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. perform on written or oral examinations
2. perform on outside assignments
3. contribute to group problem solving
4. apply theory to problem solving
5. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Basic Electronics		
A. DC theory		
1) Ohm's Law		
2) Resistors/potentiometer		
3) Series/parallel circuits/voltage dividers		
4) Calculating voltage, current, and resistance		
5) Resistive bridge circuits		
6) Conductors/insulators		
7) Switches		
8) Power		
B. Sources of electrical energy		
C. Electrical safety		
D. Component symbols		
E. Test meters		
F. Capacitance		
G. Inductance		
H. Capacitive/inductive test equipment		
I. Magnetism		
J. Electro-magnetism		
K. DC relays/solenoids		
L. DC motors/generators		
AC Theory		
A. Analysis of a sine wave		
1) Single phase AC		
2) Two phase AC		
3) Three phase AC		
B. Use of the oscilloscope		
C. Phase relationships		
D. R-C, L-R, and L-C circuits		
E. Relays/solenoids		
F. Transformer theory		
G. AC motors/generators		
Electronic Theory		
A. Semiconductors		
B. Diodes		
C. Sensors		
1) Thermocouple/RTDs		
2) Force sensors		
3) Accelerometers		
4) Photosensors		
	Total Lecture Hours	—

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

Upon successful completion of this course the student will be able to:

A. **APPLY MATHEMATICAL FORMULAS, AND THE RULES OF MATHEMATICS, TO CALCULATE AND PREDICT THE BEHAVIOR OF THE FOLLOWING QUANTITIES IN DC ELECTRONICS/ELECTRICITY: RESISTANCE, VOLTAGE, CURRENT, POWER, AND CAPACITOR-RESISTOR TIME CONSTANTS**
   1. Apply Mathematical Formulas Found in the Study of Direct Current (DC) Electronics/Electricity to Calculate and Predict the Behavior of the Following Quantities:
      a. Voltage
      b. Current
      c. Resistance
   2. Apply Mathematical Formulas to Calculate and Predict the Behavior of Circuit Components That Consume DC Electrical Power
   3. Explain the Purpose of Power and its Manifestations in DC Circuits
   4. Apply Mathematical Formulas to Calculate Time Constants and Predict the DC, Electrical Behavior of Series Resistor-Capacitor (R-C) Circuits

B. **APPLY MATHEMATICAL FORMULAS, AND THE RULES OF MATHEMATICS, TO CALCULATE AND PREDICT THE BEHAVIOR OF THE FOLLOWING QUANTITIES IN AC ELECTRONICS/ELECTRICITY; RESISTANCE, VOLTAGE ,CURRENT, POWER, INDUCTIVE REACTANCE, CAPACITIVE REACTANCE, PEAK AC VOLTAGE AND CURRENT, PEAK-TO-PEAK AC VOLTAGE AND CURRENT, RMS AND AVERAGE AC VOLTAGE AND CURRENT**
   1. Apply Mathematical Formulas Found in the Study of Alternating Current (AC) Electronics/Electricity to Calculate and Predict the Behavior of the Following Quantities:
      a. Peak voltage, current
      b. Root Means Square (RMS) voltage, current
      c. Average voltage, current
      d. Resistance
   2. Apply Mathematical Formulas and Theories Found in the Study of AC Electronics/Electricity to Calculate and Predict the Following:
      a. Inductive reactance
      b. Capacitive reactance
   3. Apply Mathematical Formulas to Calculate and Predict the Behavior of AC Circuit Components That Consume the Following Types of Power
      a. True power, capacitive, inductive
      b. Apparent power
      c. Power consumed in resistance
   4. Explain the Purpose of Power and its Manifestations in AC Circuits

C. **USE MATHEMATICAL FORMULAS, AND THE RULES OF MATHEMATICS FROM THE STUDY OF ALGEBRA, BASIC VECTOR MATHEMATICS, AND TRIGONOMETRY, TO CALCULATE AND PREDICT THE BEHAVIOR OF THE FOLLOWING QUANTITIES IN AC ELECTRONICS/ELECTRICITY;**

IMPEDANCE OF SERIES RESISTIVE- CAPACITIVE CIRCUITS, IMPEDANCE OF SERIES INDUCTIVE-RESISTIVE CIRCUITS, AND PHASE ANGLE IN THE ABOVE CIRCUITS

1. Apply Mathematical Formulas to Calculate and Predict the Behavior of Circuit Components That Contain the Following Types of Components
    a. Series resistive-capacitive circuits
    b. Series resistive-inductive circuits
    c. Series resistive-inductive-capacitive circuits
2. Apply Mathematical Formulas and Simple Vector Mathematics Found in the Study of AC Electronics/Electricity to Calculate and Predict Phase Angle in the above Circuits

D. APPLY THE RULES OF AC ELECTRONICS/ELECTRICITY, TO PREDICT AND MEASURE THE VOLTAGE, CURRENT POWER, AND PHASE ANGLE IN THREE PHASE AC CIRCUITS

1. Explain the Characteristics of the Following Types of Three Phase AC Circuits
    a. Delta
    b. Wye
2. Apply the Rules of Trigonometry and Algebra to Calculate RMS and Peak Voltages and Currents in the above Circuits
3. Apply the Rules of Trigonometry and Algebra to Calculate True Power, Apparent Power, and Power Factor in the above Circuits
4. Apply Trigonometry, Simple Vector Mathematics, and the Rules of Reactive Circuits to Calculate the Values of Inductance or Capacitance Needed to Provide Power Factor Correction for a Power Distribution System

E. PROPERLY SETUP, CALIBRATE, AND USE METERS, FUNCTION GENERATORS, AND OSCILLOSCOPES TO ACCURATELY TEST RESISTANCE, VOLTAGE, CURRENT, FREQUENCY, AND TIME; IN BOTH DC AND AC CIRCUITS

1. Properly Setup, Connect and Read the Following Types of Meters:
    a. Analog multimeters
    b. Digital multimeters
2. Using the above Meters, Properly and Safely Test Voltage, Current, or Resistance in DC and AC Circuits

F. USE COMPONENTS SUCH AS RESISTORS, INDUCTORS, AND CAPACITORS TO CONSTRUCT CIRCUITS, AND TEST THE COMPONENTS IN BOTH DC AND AC CIRCUITS, TO DETERMINE IF THE COMPONENTS ARE OPERATING PROPERLY

1. Assemble Electrical/Electronic Components to Create Working Circuits.
    a. Construct the following resistive circuits
        1) Series
        2) Parallel
        3) Bridge circuits.
    b. Construct the following capacitive/inductive circuits
        1) Series capacitive-resistive
        2) Series inductive-resistive
        3) Series inductive-capacitive-resistive
2. Test Components the above Components in DC Circuits
3. Test Components the above Components in AC Circuits

G. USE OSCILLOSCOPES, METERS, AND THE METROLOGY OF ELECTRICAL MEASUREMENT, TO MEASURE PHASE SHIFT AND PHASE ANGLE IN SERIES RESISTIVE-CAPACITIVE AND SERIES RESISTIVE-INDUCTIVE AC CIRCUITS

1. Properly Set up an Oscilloscope to Measure Frequency
2. Using the Oscilloscope, and Proper Measurement Techniques, Measure the Phase Shift in the Following AC Circuits:
    a. Series capacitive-resistive
    b. Series inductive-resistive
    c. Series inductive-capacitive-resistive

H. APPLY THE THEORY OF ELECTRO-MAGNETISM, TO EXPLAIN THE OPERATION OF MAGNETICALLY COUPLED DEVICES SUCH AS RELAYS, SOLENOIDS, TRANSFORMERS, AND ELECTRICAL MOTORS

1. Explain the Purpose of Magnetism in the Control of Electrical and Electronic Devices
2. Explain the Role of Inductors in the Generation of Magnetic Fields
3. Explain the Method of Generating Magnetic Fields and the Method of Controlling Them for Both DC and AC Magnetically Operated Devices
4. Apply the Knowledge of Electro-magnetism to Explain the Operation of the Following Devices:
    a. Relays
    b. Solenoids
    c. Transformers
    d. Electrical motors

I. USE METERS, FUNCTION GENERATORS, AND OSCILLOSCOPES; TO TEST MAGNETICALLY COUPLED DEVICES SUCH AS RELAYS, SOLENOIDS, TRANSFORMERS, AND ELECTRICAL MOTORS TO DETERMINE IF THEY ARE OPERATING PROPERLY

1. Use Ohmmeters and Megohm Meters to Test Resistance and Insulation Resistance of the Following Inductive Devices:
    a. Relays
    b. Solenoids
    c. Transformers
    d. Electrical motors
2. Use Multimeters and Clamp-on Volt Ammeters to Test Voltage and Current in the above Devices
3. Use Function Generators and Oscilloscopes to Test Phase Shift in the above AC Devices

J. IDENTIFY DC MOTORS SUCH AS PERMANENT MAGNETIC DC MOTORS, SERIES FIELD DC MOTORS, SHUNT FIELD DC MOTORS, COMBINATION DC MOTORS, AND UNIVERSAL MOTORS

1. Identify the Following Types of DC Motors
    a. Permanent magnet DC motors
    b. Shunt field DC motors
    c. Series field DC motors
    d. Combination series-shunt field DC motors
    e. Universal motors operating on DC

2. Explain the Purpose, Characteristics, and Operating Principles of the Following for Each Type of Motor:
    a. Armature
    b. Field, including field weakening
    c. Brushes and brush holder

K. IDENTIFY AC MOTORS SUCH AS: SPLIT PHASE CAPACITIVE START MOTORS, SPLIT PHASE CAPACITIVE START-CAPACITIVE RUN MOTORS, INDUCTIVE START-INDUCTIVE-RUN MOTORS, THREE PHASE SQUIRREL CAGE MOTORS, AND UNIVERSAL MOTORS

1. Identify the Following Types of AC Motors:
    a. Split phase capacitive-start AC motors
    b. Split phase capacitive-start capacitive run AC motors
    c. Inductive start-inductive-run AC motors
    d. Universal motors operating on AC
    e. Three phase squirrel cage motors AC
    f. Fully synchronous AC motors
2. Explain the Characteristics and Operating Principles of the Starter and Rotor for Each Type of Motor

L. USE THE RULES OF SEMICONDUCTOR DIODES SUCH AS BARRIER POTENTIAL, PIV, FORWARD BIAS, AND REVERSE BIAS; TO TEST FRONT-TO-BACK RATIOS, AND MEASURE FORWARD AND REVERSE VOLTAGE DROP

1. Explain the Electrical Characteristics of Semiconductors Materials Such as Germanium and Silicon
2. Explain the Methods That Are Used to Change the Electrical Characteristics of Semiconductors
3. Explain the Construction of a Semiconductor Junction Diode
4. Explain the Following Characteristics of Semiconductor Junction Diodes
    a. Barrier potential
    b. Peak inverse voltage (PIV)
    c. Depletion region
    d. Forward bias voltage drop
    e. Reverse bias
5. Test the Following Characteristics of Semiconductor Junction Diodes
    a. Resistive front-to-back ratios
    b. Forward bias voltage drop
    c. Reverse bias voltage drop
    d. Forward bias current
    e. Reverse bias current

M. SAFELY ASSEMBLE OR DISASSEMBLE ELECTRICAL SYSTEMS OR COMPONENTS

1. Explain the Role of Resistance, Voltage and Current in Assessing Electrical Hazards
2. Explain the Procedures Used to Minimize Exposure to Electrical Hazards
3. Explain the Purpose of CPR to Revive Victims of Electrical Shock
4. Explain the Safety Precautions Used When Testing Live Equipment
5. Demonstrate Lock-out, Tag-out Procedures

    6. Demonstrate Proper Tools and Procedures Used to Assemble or Disassemble Electrical Components

N. SAFELY ASSEMBLE OR DISASSEMBLE ELECTRONIC SYSTEMS OR COMPONENTS

    1. Explain the Role of Resistance, Voltage and Current in Assessing Electronic Hazards
    2. Explain the Procedures Used to Minimize Exposure to Electronic Hazards
    3. Explain the Safety Precautions Used When Testing Live Equipment
    4. Explain the Purpose of CPR to Revive Victims of Electrical Shock
    5. Explain the Concept of Electro-static Discharge and the Proper Procedures Used to Minimize its Effects
    6. Demonstrate Lock-out, Tag-out Procedures
    7. Demonstrate Proper Tools and Procedures Used to Assemble or Disassemble Electronic Components

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

- *A.* ***Resources:*** *Identifies, organizes, plans, and allocates resources*
    1. allocates time
        a. completes assigned work on time
        b. successfully completes timed examinations
- *B.* ***Interpersonal:*** ***Works with others***
    1. participates as a member of a team
        a. participates in team lab projects
        b. participates in study groups
    2. teaches others
        a. helps team members solve problems
        b. contributes information to teams/study groups
    3. satisfies instructor assigned requirements
    4. exercises leadership
        a. forms study groups
        b. motivates teams/study groups to succeed
        c. expresses ideas, feelings, and opinions clearly
        d. identifies whether the source of a position is an idea, feeling, or opinion

e. provides supporting facts to support positions
5. expresses ideas and listens to others to solve team problems
6. works well with team and class members regardless of race class, ethnicity, or religion

C. *Information: Acquires and uses information*
1. acquires and evaluates information
a. obtains new or complementary information for various sources such as:
1) text books
2) lectures
3) library
4) periodicals
5) internet
b. evaluates information for accuracy, challenges information that contradicts logical evaluation
2. keeps and maintains an organized class lab workbook
3. gives oral/written presentations to class

D. Systems: Understands complex inter-relationships
1. understands systems
a. understands complex electrical and electronic systems
b. understands the behavior of electrical control circuitry
2. monitors and corrects performance
a. tests electrical or electronic systems to determine if they are meeting theoretical expectations
b. corrects systems or theory from results of evaluation
3. finds alternate methods to test electronic systems

E. Technology: Works with a variety of technologies
1. selects appropriate technology
a. uses meters, function generators, and oscilloscopes
b. selects proper test equipment for electrical or electronic measurements
2. applies technology to the tests/measurements
3. troubleshoots electrical or electronic systems

II. FOUNDATION SKILLS

A. Basic Skills: Reads, writes, performs arithmetic and mathematical operations, listens and speaks.

1. *Reading: Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
a. reads assigned course material
b. interprets reading material to perform successfully in class
c. interprets laboratory data/graphs

2. *Writing: Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
a. creates lab reports from laboratory data
b. writes report/term paper on industrial electrical or electronic systems

3. ***Arithmetic/Mathematics:** Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    - a. performs mathematical computations using scientific notation and engineering notation
    - b. applies the principles of algebra, geometry, and trigonometry to solve technical problems
4. ***Listening:** Receives, attends to, interprets, and responds to verbal messages and other cues*
    - a. actively listens to the information being presented in class and feeds back concepts
    - b. listens to the ideas, feelings, and opinions of fellow classmates
5. ***Speaking:** Organizes ideas and communicates orally*
    - a. presents ideas and information in class
    - b. contributes to classroom discussion

B. ***Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. ***Creative Thinking:** Generates new ideas*
    - a. understands the principles of open and closed in terms of electrical or electronic systems
    - b. applies math, physics, and chemistry to the analysis of complex electrical or electronic systems
2. ***Decision Making:** Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    - a. uses formulas and mathematics to predict the limits of behavior of electrical or electronic systems
    - b. uses formulas and mathematics to determine alternate/desirable changes in electrical or electronic systems
3. ***Problem Solving:** Recognizes problems and devises and implements plan of action*
    - a. uses mathematics and the knowledge of electrical or electronic circuits to solve problems in industrial systems
    - b. chooses desired course of action based upon results of analysis .
4. ***Seeing Things In the Mind's Eye:** Organizes, and processes symbols, pictures, graphs, objects, and other information*
    - a. uses scientific principles, symbolic diagrams, and the knowledge of electricity or electronics to visualize the complex interrelationships of parts of electrically controlled industrial systems
5. ***Knowing How to Learn:** Use efficient learning techniques to acquire and apply new knowledge and skills*
    - a. uses effective study techniques to acquire new class material
    - b. practices to acquire new skills
6. ***Reasoning:** Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    - a. applies the principles of electronics to the understanding of the behavior of an industrial machine
    - b. applies the concept of entropy to the understanding of power transmission systems, and heat engines

        c. understands the relationship between power and heat

C. ***Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

- 1. ***Responsibility:** Exerts a high level of effort and perseveres towards goal attainment*
    - a. performs at or above expected class level
    - b. sets individual/group goals and accomplishes them
- 2. ***Self-Esteem:** Believes in own self-worth and maintains a positive view of self*
    - a. contributes to classroom discussion with original ideas
    - b. maintains a positive sense of humor that is not at the expense of another person's sense of self worth
- 3. ***Sociability:** Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    - a. allows divergent views in class discussions
    - b. responds positively to new ideas
    - c. supports the worthwhile goals and objectives of the team and fellow classmates
- 4. ***Self-Management:** Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    - a. accepts responsibility for completion of assigned work
    - b. sets individual/group goals and accomplishes them
    - c. maintains a record of accomplishments
- 5. ***Integrity/Honesty:** Chooses ethical courses of action*
    - a. performs own work when required, does not plagiarize the work of others
    - b. protects school property
    - c. does not misappropriate the property of the school or other classmates
    - d. reports infractions of school rules to school authorities

Appropriate Reference Materials:

1. Maintaining and Troubleshooting Electrical Equipment by Parks/Wireman, 1987

MAFG200
05/062896

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program
MAST

COURSE SYLLABUS

MOTION CONTROL/SERVO SYSTEMS

MAST PROGRAM
COURSE SYLLABUS
MOTION CONTROL/SERVO SYSTEMS

Lecture hours/week: 2 **Lab hours/week: 6** **Credit hours: 4**

COURSE DESCRIPTION:

This course involves the study of the types of control circuits used to control industrial equipment, including motor , process , and hydraulic controls. In addition, this course includes the types of feedback systems employed in control systems and their theory of operation. An emphasis will be placed upon closed loop servo systems and their theory of operation. The students will experience hands-on interaction with these control systems through laboratory experiments. (FT) Associate Degree Credit

PREREQUISITES: **Satisfactory completion of Industrial Electronics/Electricity with a grade of "C" or better, or equivalent.**

COURSE OBJECTIVES:

Upon successful completion of this course, the student will:

1. Use test equipment such as a meter or oscilloscope to test diodes, bipolar transistors, and power MOSFETs, both in and out of the circuit
2. Use test equipment such as a meter or oscilloscope to test SCRs (Thyristors), triacs, and their associated triggering devices such as UJTs, PUTs, diacs, and SBSs, both in and out of circuit
3. Use test equipment such as a meter or oscilloscope to test DC power supplies, including rectifiers, filtering capacitors, filtering inductors, and semiconductor devices found in power supply regulators, such as bi-polar transistors and power MOSFETs
4. Use a schematic diagram and test equipment such as a meter or oscilloscope to test, troubleshoot, and repair series, shunt, and switching regulators in DC power supplies
5. Identify, test, troubleshoot, and repair various types of motor control circuits such as DC motor controls, permanent magnet motor controls, DC shunt field motor controls, and universal motor controls
6. Identify, test, troubleshoot, and repair motor control circuits such as SCR motor controls, pulse-width modulated motor controls, and three-phase inverter type motor controls
7. Test electrical devices such as relays, contacts, solenoids, and switches, both in and out of circuit
8. Test sensors such as pressure transducers, photoelectric sensors, and proximity sensors
9. Identify and test various types of servo control systems such as bang-bang servos, type 0 servo systems, type 1 servo systems, type 2 servo systems and the types of feedback employed in these systems
10. Apply the formulas and concepts of the study of servo systems, such as following error (steady state error), gain, integral and derivative to the solution of problems in point-to-

point servo systems, contouring servo systems, and proportional-band-integral-derivative (PID) servo systems

REQUIRED COURSE MATERIALS:

Textbook: An example of a text which would be appropriate for this course is: Modern Industrial Electronics, Revised and Expanded Edition by Schuler/MacNamee, 1992 (formerly, Industrial Electronics and Robotics by Schuler/McNamee, 1987)

Lab Materials: Students will be required to purchase the following supplies:

1) Paper, notebooks and writing instruments
2) Safety glasses
3) Scientific calculator, Scantron examination sheets

METHODS OF INSTRUCTION:

Lecture: Presentations will include lecture, demonstration, and group problem solving.

Laboratory: Laboratory will be "hands-on" exploration and problem solving.

Group Projects: Group projects will be assigned during the lab periods. Each set of projects will provide practice in one or more concepts. The students will work on problems that are derived from manufacturing or industrial situations. Any problems not solved by the team will be assigned as homework problems. The individual grade for these tasks will be a combination of a team grade, and a team assessment of the individual's contribution to the team's efforts. The instructor will devise a method whereby the team's assessment of an individual's contributions is fair and free of bias.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. perform on written or oral examinations
2. perform on outside assignments
3. contribute to group problem solving
4. apply theory to problem solving
5. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topic	Text Reference Page	Contact Hrs.
Solid State Components		
A. Diodes		
B. Bi-polar transistors		
C. Field effect transistors, JFETs,		

MOSFETs
D. SCRs, TRIACs, DIACs
E. Integrated circuits

Amplifiers
A. Transistor amplifiers
B. Operational amplifiers

Power Control Circuits
A. Power supplies
B. SCR power control circuits
C. Transistor power control circuits
D. Three phase motor invertor control circuits
E. Types of motors

Hydraulic and Pneumatic Controls
A. Switches, relays
B. Solenoids
C. Amplifier circuits for hydraulic and pneumatic systems

Closed Loop Controls
A. Motor controls
B. Process controls
C. Hydraulic/pneumatic controls

Feedback Devices
A. Transducers
B. Digital feedback devices
C. Analog feedback devices
D. Phase analog feedback devices

Closed Loop Servo Systems
A. Bang-bank servos
B. Proportional-band-integral-derivative (PID) servos
C. Gain block algebra for servo systems

Total Lecture Hours —

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

Upon successful completion of this course the student will be able to:

A. USE TEST EQUIPMENT SUCH AS A METER OR OSCILLOSCOPE TO TEST DIODES, BIPOLAR TRANSISTORS, AND POWER MOSFETS, BOTH IN AND OUT OF THE CIRCUIT

1. Use Multimeters to Test Resistance, Voltage, and Current Characteristics of the Following Types of Semiconductor Diodes:
    a. Low and high power silicon junction diodes
    b. Zener diodes
    c. Transient suppression diodes (bi-directional breakdown diodes)
    d. Light emitting diodes

        - e. Photo-diodes
        - f. Bridge rectifiers
    2. Use Multimeters to Test Resistance, Voltage and Current Characteristics of the Following Types of Transistors:
        - a. Low and high power bi-polar junction transistors
        - b. Uni-polar field effect transistors, including high power Metal Oxide Semiconductor (MOSFET) transistors
    3. Test the Devices Both in and out of Circuit
    4. Use Oscilloscopes to Measure the In-circuit, Wave-Form Characteristics of the above Devices

B. USE TEST EQUIPMENT SUCH AS A METER OR OSCILLOSCOPE TO TEST SCRS (THYRISTORS), TRIACS, AND THEIR ASSOCIATED TRIGGERING DEVICES SUCH AS UJTS, PUTS, DIACS, AND SBSS BOTH IN AND OUT OF CIRCUIT

1. Use Multimeters to Test Resistance, Voltage, and Current Characteristics of the Following Types of Semiconductor Power Control Devices:
    - a. Silicon Controlled Rectifiers (SCR) Thyristors)
    - b. Triode AC Semiconductor Switch (TRIAC)
    - c. Gate Turn On (GTO) thyristor
2. Use Multimeters to Test Resistance, Voltage and Current Characteristics of the Following Types of Timing Control, Triggering Semiconductors:
    - a. Unijunction Transistors (UJT)
    - b. Programmable Unijunction Transistor (PUT)
    - c. Bi-directional break-down transistor (DIAC)
    - d. Silicon bi-lateral switch (SBS) and silicon unilateral switch (SUS)
3. Test the Devices Both in and out of Circuit
4. Use Oscilloscopes to Measure the In-circuit, Wave-form Characteristics of the above Devices

C. USE TEST EQUIPMENT SUCH AS A METER OR OSCILLOSCOPE TO TEST DC POWER SUPPLIES, INCLUDING RECTIFIERS, FILTERING CAPACITORS, FILTERING INDUCTORS, AND SEMICONDUCTOR DEVICES FOUND IN POWER SUPPLY REGULATORS, SUCH AS BI-POLAR TRANSISTORS AND POWER MOSFETs

1. Use Multimeters to Test In-Circuit Resistance, Voltage, and Current Characteristics of the Following Types of Dc, Electronic Power Supply Components:
    - a. Rectifiers
        - 1) Half wave
        - 2) Full wave
        - 3) Bridge rectifiers
    - b. Filtering components
        - 1) Capacitors
        - 2) Inductors
    - c. Semiconductor voltage and current regulating components
        - 1) Bi-polar transistors
        - 2) Power MOSFETs
        - 3) SCR (used in crowbar circuits)

2. Use Oscilloscopes to Measure the In-circuit, Wave-form Characteristics of the above Devices When Used in a DC, Electronic Power Supply

D. USE A SCHEMATIC DIAGRAM AND TEST EQUIPMENT SUCH AS A METER OR OSCILLOSCOPE TO TEST, TROUBLESHOOT, AND REPAIR SERIES, SHUNT, AND SWITCHING REGULATORS IN DC POWER SUPPLIES

1. Explain the Theory of Operation of the Following Types of DC Electronic Power Supply Regulator Circuits:
    a. Series regulators
    b. Shunt regulators
    c. Switching regulators
2. Use a Schematic Diagram to Indicate the Direction of Current Flows, Magnitude of Voltages and the Values of Components in the above Regulators
3. Explain the Expected Results If One or More of the Active Components in the above Regulators Were to Fail Open or Short
4. Use Multimeters and Oscilloscopes to Measure Resistance, Voltage, Current, and Wave Forms in the above Regulators

E. IDENTIFY, TEST, TROUBLESHOOT, AND REPAIR VARIOUS TYPES OF MOTOR CONTROL CIRCUITS SUCH AS DC MOTOR CONTROLS, PERMANENT MAGNET MOTOR CONTROLS, DC SHUNT FIELD MOTOR CONTROLS, AND UNIVERSAL MOTOR CONTROLS

1. Identify the Following Types of DC Motor Control Circuits:
    a. Standard DC motor control circuits, including the following:
        1) IR compensation
        2) Speed regulation
        3) Over current protection
        4) Field voltage
    b. Permanent magnet motor control circuits, including the following
        1) IR compensation
        2) Speed regulation
        3) Over current protection
        4) Tachometer feedback
    c. DC shunt field motor control circuits, including the following
        1) IR compensation
        2) Speed regulation
        3) Over current protection
        4) Tachometer feedback
        5) Field weakening
        6) Dynamic braking
    d. Universal motor control circuits
2. Explain the Theory of Operation of the above Motor Control Circuits
3. Explain the Concept of Regeneration
4. Use Multimeters and Oscilloscopes to Test and Adjust the above Motor Control Circuits
5. Explain the Results of a Failure in One or More of the Major Components in the above Motor Control Circuits

F. IDENTIFY, TEST, TROUBLESHOOT, AND REPAIR MOTOR CONTROL CIRCUITS SUCH AS SCR MOTOR CONTROLS, PULSE-WIDTH

MODULATED MOTOR CONTROLS, AND THREE-PHASE INVERTER TYPE MOTOR CONTROLS

1. Identify the Following Types of Specialized Motor Control Circuits:
    a. Single phase AC motor control circuits, including the following:
        1) Half wave universal motor control circuits
        2) Full wave universal motor control circuits
    b. Three phase variable frequency inverter type motor control for inductive motors, including the following
        1) Volts per Hertz ratios
        2) Chopper type voltage regulation
        3) Three phase full wave rectifier- SCR voltage regulators
        4) Speed control and tachometer feedback
        5) Instantaneous over current protection
        6) Regeneration
    c. Pulse width modulated DC motor control circuits, including the following
        1) Duty cycle
        2) Speed regulation
        3) Over current protection
        4) Tachometer feedback
        5) Field weakening
        6) Dynamic braking
2. Explain the Theory of Operation of the above Motor Control Circuits
3. Use Multimeters and Oscilloscopes to Test and Adjust the above Motor Control Circuits
4. Explain the Results of a Failure in One or More of the Major Components in the above Motor Control Circuits

G. TEST ELECTRICAL CONTROL DEVICES SUCH AS RELAYS CONTACTS, AND SWITCHES, BOTH IN AND OUT OF CIRCUIT

1. Identify the Following Switching Devices:
    a. Relays
    b. Toggle switches
    c. Push button switches
    d. Wafer switches
    e. Multi-pole rotary switches
2. Explain the Concept of Open or Close as it Pertains to Switching Devices
3. Use Multimeters to Test Resistance of and Voltage Drop Across Electrical Contacts of the above Switching Devices
4. Determine If the Device Is Open or Closed from the Results of Tests

H. TEST SENSORS SUCH AS PRESSURE TRANSDUCERS, PHOTOELECTRIC SENSORS, AND PROXIMITY SENSORS

1. Identify the Following Types of Sensors
    a. Temperature
        1) Thermocouple
        2) Resistance Temperature Detector (RTD)
        3) Semiconductor temperature devices
    b. Pressure
    c. Flow
    d. Level

- e. Force
    - 1) Strain gages
    - 2) Piezoelectric
- f. Photoelectric
    - 1) Photo-resistor
    - 2) Photo-diode
    - 3) Photo-voltaic (solar cell)
    - 4) Photo-transistor
    - 5) Photo-SCR
- g. Proximity sensors
    - 1) Inductive
    - 2) Capacitive
    - 3) Photoelectric

2. Explain the Theory of Operation of the above Devices and the Physical Quantities That They Measure
3. Use Multimeters, Oscilloscopes and Laboratory Standards to Test and Calibrate the above Devices

I. IDENTIFY AND TEST VARIOUS TYPES OF SERVO CONTROL SYSTEMS SUCH AS BANG-BANG SERVOS, TYPE 0 SERVO SYSTEMS, TYPE 1 SERVO SYSTEMS, TYPE 2 SERVO SYSTEMS, AND THE TYPES OF FEEDBACK EMPLOYED IN THESE SYSTEMS

1. Identify the Following Types of Servo Systems:
    - a. Open loop servo systems:
        - 1) Bang-bang servos
        - 2) Stepper motor servos
    - b. Closed loop servo systems:
        - 1) Type 0 point to point positioning servos
        - 2) Type 1 velocity control servos
        - 3) Type 2 Acceleration control servos
        - 4) Combination type 0 and 1 servos (continuous path or contouring servos)

J. IDENTIFY AND TEST VARIOUS TYPES OF SERVO CONTROL SYSTEMS SUCH AS BANG-BANG SERVOS, TYPE 0 SERVO SYSTEMS, TYPE 1 SERVO SYSTEMS, TYPE 2 SERVO SYSTEMS, AND THE TYPES OF FEEDBACK EMPLOYED IN THESE SYSTEMS

1. Identify the Subsystems Used in the Different Classes of Servo Systems
2. Identify the Following Motive Force Generators Used in Complex Servo Systems:
    - a. AC servo motors
    - b. Stepper motors
    - c. DC permanent magnet servo motors
    - d. DC brushless servo motors
    - e. Heating elements
    - f. Fluid control valves
        - 1) Hydraulic servo valves
        - 2) Hydraulic proportioning valves
        - 3) Pressure control valves (pressure reducing and pressure relief)
        - 4) Flow control servo valves

3. Identify the Following Types of Feedback Devices Used in Complex Servo Systems:
    a. Tachometer
    b. Resolver (linear and rotary)
    c. Linear variable differential transformer (LVDT)
    d. Rotary and linear optical encoder (transducer) (ROT) (LOT)
    e. Magnetic scale transducer
    f. Laser interferometer
4. Identify the Following Types of Operational Amplifier Circuits Used in Complex Servo Systems:
    a. Summing amplifiers
    b. Subtraction amplifiers
    c. Integration amplifiers
    d. Derivation amplifiers
    e. Compensation amplifiers
    f. Comparators
5. Explain the Theory of Operation of the above Systems, Subsystems, Circuits, and Components
6. Use Multimeters, Function Generators, and Oscilloscopes to Test the Operational Characteristics of the above Systems, Subsystems, Circuits and Components
7. Use Test Equipment and Laboratory Standards to Adjust and Calibrate the above Systems, Subsystems, Circuits and Components

K. APPLY THE FORMULAS AND CONCEPTS OF THE STUDY OF SERVO SYSTEMS, SUCH AS FOLLOWING ERROR (STEADY STATE ERROR), GAIN, INTEGRAL, AND DERIVATIVE TO THE SOLUTION OF PROBLEMS IN POINT-TO-POINT SERVO SYSTEMS, CONTOURING SERVO SYSTEMS, AND PROPORTIONAL-BAND-INTEGRAL-DERIVATIVE (PID) SERVO SYSTEMS

1. Use Gain Block Algebra to Identify and Analyze the Characteristics of the Following Closed Loop Servo Systems:
    a. Type 0 point to point positioning servos
    b. Type 1 velocity control servos
    c. Combination type 0 and 1 servos (continuous path or contouring servos)
2. Explain the Concept of Following Error (Steady State Error) and the Effects on Following Error of the Following:
    a. Gain
    b. Feedback
    c. Summation amplifiers
    d. Compensation amplifiers
3. Explain the Concept of Proportional-Band (Gain), Integral, and Derivative as to it Effects on the Following:
    a. Set point (position)
    b. Following error
4. Use Function Generators and Digital Storage Oscilloscopes to Set up the Following on the above Closed Loop Servo Systems
    a. Step functions
    b. Ramp functions
5. Adjust Proportional Band, Integral and Derivative on a PID Loop Controller and Observe the Effects of Each on the Controlled Process

L. SAFELY ADJUST ELECTRICAL SYSTEMS OR COMPONENTS

1. Explain the Role of Resistance, Voltage and Current in Assessing Electrical Hazards
2. Explain the Procedures Used to Minimize Exposure to Electrical Hazards
3. Explain the Safety Precautions Used When Testing or Adjusting Live Equipment

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

- *A.* ***Resources:*** *Identifies, organizes, plans, and allocates resources*
    - 1. allocates time
        - a. completes assigned work on time
        - b. successfully completes timed examinations
- *B.* ***Interpersonal:*** *Works with others*
    - 1. participates as a member of a team
        - a. participates in team lab projects
        - b. participates in study groups
    - 2. teaches others
        - a. helps team members solve problems
        - b. contributes information to teams/study groups
    - 3. satisfies instructor assigned requirements
    - 4. exercises leadership
        - a. forms study groups
        - b. motivates teams/study groups to succeed
        - c. expresses ideas, feelings, and opinions clearly
        - d. identifies whether the source of a position is an idea, feeling, or opinion
        - e. provides supporting facts to support positions
    - 5. expresses ideas and listens to others to solve team problems
    - 6. works well with team and class members regardless of race class, ethnicity, or religion
- *C.* ***Information:*** *Acquires and uses information*
    - 1. acquires and evaluates Information
        - a. obtains new or complementary information for various sources such as:
            - 1) text books

        2) lectures
        3) library
        4) periodicals
        5) internet
      b. evaluates information for accuracy, challenges information that contradicts logical evaluation
    2. keeps and maintains an organized class lab workbook
    3. gives oral/written presentations to class

  D. ***Systems:** Understands complex inter-relationships*
    1. understands systems
      a. understands complex electronic systems
      b. understands the connections between machines and electronics and the role of electronics in industrial systems
    2. monitors and corrects performance
      a. tests electronic systems to determine if they are meeting theoretical expectations
      b. corrects systems or theory from results of evaluation
    3. finds alternate methods to test electronic systems

  E. ***Technology:** Works with a variety of technologies*
    1. selects appropriate technology to perform electronic measurements
    2. applies technology to the tests/measurements
    3. troubleshoots electronically controlled industrial systems and processes

II. FOUNDATION SKILLS

  A. ***Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*
    1. ***Reading:** Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
      a. reads assigned course material
      b. interprets reading material to perform successfully in class
      c. interprets laboratory data/graphs
    2. ***Writing:** Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
      a. creates lab reports from laboratory data
      b. writes report/term paper on industrial electronic systems
    3. ***Arithmetic/Mathematics:** Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
      a. performs mathematical computations using scientific notation and engineering notation
      b. applies the principles of algebra, geometry, and trigonometry to solve control problems
    4. ***Listening:** Receives, attends to, interprets, and responds to verbal messages and other cues*
      a. actively listens to the information being presented in class and feeds back concepts
      b. listens to the ideas, feelings, and opinions of fellow classmates

5. *Speaking: Organizes ideas and communicates orally*
    a. presents ideas and information in class
    b. contributes to classroom discussion

B. ***Thinking Skills:** Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*
1. ***Creative Thinking:** Generates new ideas*
    a. combines the principles of physics and chemistry to the understanding of complex manufacturing processes
    b. applies math, physics, and chemistry to the analysis of complex industrial equipment such as heat treating furnaces, water treatment systems, high vacuum systems
2. ***Decision Making:** Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. uses formulas and mathematics to predict the limits of behavior of industrial systems
    b. uses formulas and mathematics to determine alternate/desirable changes in industrial systems
3. ***Problem Solving:** Recognizes problems and devises and implements plan of action*
    a. uses mathematics, physics, and chemistry to solve problems in industrial systems
    b. chooses desired course of action based upon results of analysis
4. ***Seeing Things In the Mind's Eye:** Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. uses scientific principles, symbolic diagrams, and mathematics to visualize the complex interrelationships of parts of industrial systems
5. ***Knowing How to Learn:** Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. uses effective study techniques to acquire new class material
    b. practices to acquire new skills
6. ***Reasoning:** Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. applies the principles of electronics to the understanding of the behavior of an industrial machine
    b. applies the concept of entropy to the understanding of power transmission systems, and heat engines
    c. understands the relationship between power and heat

C. ***Personal Qualities:** Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*
1. ***Responsibility:** Exerts a high level of effort and perseveres towards goal attainment*
    a. performs at or above expected class level
    b. sets individual/group goals and accomplishes them
2. ***Self-Esteem:** Believes in own self-worth and maintains a positive view of self*
    a. contributes to classroom discussion with original ideas

b. maintains a positive sense of humor that is not at the expense of another person's sense of self worth

3. ***Sociability:** Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
   a. allows divergent views in class discussions
   b. responds positively to new ideas
   c. supports the worthwhile goals and objectives of the team and fellow classmates
4. ***Self-Management:** Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
   a. accepts responsibility for completion of assigned work
   b. sets individual/group goals and accomplishes them
   c. maintains a record of accomplishments
5. ***Integrity/Honesty:** Chooses ethical courses of action*
   a. performs own work when required, does not plagiarize the work of others
   b. protects school property
   c. does not misappropriate the property of the school or other classmates
   d. reports infractions of school rules to school authorities

Appropriate Reference Materials:

1. Motion Control, Pub of Instrument Society of America (ISA)
2. Industrial Computing, Pub of Instrument Society of America (ISA)
3. SME Journal, Pub of Society of Manufacturing Engineers (SME)
4. Manufacturing Engineering, Pub of Society of Manufacturing Engineers (SME)

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program
MAST

COURSE SYLLABUS

FLUID POWER TECHNOLOGY

MAST PROGRAM
COURSE SYLLABUS
FLUID POWER TECHNOLOGY

Lecture hours/week: 2 **Lab hours/week: 3** **Credit hours: 3**

COURSE DESCRIPTION:

This course will investigate the basic principles of hydraulics and pneumatics through the use of hands-on experiments and classroom lectures. In addition, this course will explore various hydraulic and pneumatic systems, circuits, components, and applications. (FT) Associate Degree Credit

PREREQUISITES: **Print Reading and Symbology and Manufacturing Processes, each with a grade of "C" or better, or the equivalent**

COURSE OBJECTIVES:

Upon successful completion of this course, the student will be able to:

1. Use the text and classroom lectures to demonstrate the use of major systems that comprise a hydraulic or pneumatic system such as pumps, tanks, plumbing, fluid, rotary actuators, linear actuators, flow control valves, pressure control valves, directional control valves, pilot-operated hydraulic and pneumatic components, and solenoid operated hydraulic and pneumatic components
2. Apply formulas and mathematics to calculate force, pressure, volume, horsepower, rod speed for linear actuators, rotational speed for rotary actuators, pumping rates for pumps, and pressures in various scales for both hydraulic and pneumatic systems
3. Using pneumatic and hydraulic system, the learner will demonstrate the effects of pressure upon the volume of fluid or air in the system
4. Using a pneumatic and a hydraulic system, the learner will demonstrate the effects of system pressure upon actuator speed
5. Using a pneumatic and hydraulic system, the learner will demonstrate the effects of system flow upon actuator speed
6. Using a pneumatic system, a hydraulic system, and directional control valves, the learner will measure pressure drops as a function of flow, the method of diverting flow, and the leakage rate of the valves
7. Using a pneumatic and hydraulic system, the learner will measure the cracking pressure and operating characteristics of pressure control valves
8. Using a hydraulic system, the learner will demonstrate the function and operating characteristics of hydraulic accumulators
9. Using a pneumatic and hydraulic system, the learner will connect, measure, and demonstrate the operating characteristics of a regenerative circuit, an intensifier circuit, a counter balance circuit, a sequencing circuit, an unloading accumulator circuit, an accumulator emergency power circuit, a venturi circuit, and electrical control of hydraulic and pneumatic circuits

10. Using a pneumatic and hydraulic system, the learner will demonstrate the proper instruments and troubleshooting methods used for fluid power circuits

REQUIRED COURSE MATERIALS:

Textbook:	An example of a text which would be appropriate for this course is: Industrial Hydraulic Technology, 2nd Edition by Parker Hannifin Inc., 1993
Lab Materials:	Students will be required to purchase the following supplies: 1) Paper, notebooks and writing instruments 2) Protective lab apron, safety glasses 3) Scientific calculator 4) Scantron examination sheets

METHODS OF INSTRUCTION:

Lecture:	Presentations will include lecture, demonstration, and group problem solving.
Laboratory:	Laboratory will be a "hands-on" mathematical problem solving.
Group Projects:	Group projects will be assigned during the lab periods. Each set of projects will provide practice in one or more concepts. The students will work on problems that are derived from manufacturing or industrial situations. Any problems not solved by the team will be assigned as homework problems. The individual grade for these tasks will be a combination of a team grade, and a team assessment of the individual's contribution to the team's efforts. The instructor will devise a method whereby the team's assessment of an individual's contributions is fair and free of bias.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. perform on written or oral examinations
2. perform on outside assignments
3. contribute to group problem solving
4. apply theory to problem solving
5. maintain attendance as per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Hydraulic and Pneumatic Safety		
Basic Physical Laws for Fluid Power		
A. Pressure, force		
B. Flow rate, velocity		
C. Work, power and horsepower		

D. Hydrostatic systems
E. Hydrodynamic systems

Hydraulics

A. Fluid power symbols
B. Fluid properties
C. Fluid storage, conditioning
D. Fluid transmission
E. Hydraulic pumps
F. Control valves:
    1) Pressure
    2) Directional
    3) Flow
G. Actuators:
    1) Linear
    2) Rotary
H. Hydraulic circuits
I. Troubleshooting

Pneumatics

A. Pneumatic symbols
B. Gas properties
C. Transmission of gas for pneumatics
D. Compressors
E. Control valves:
    1) Pressure
    2) Directional
    3) Flow
F. Actuators:
    1) Linear
    2) Rotary
G. Venturies
H. Pneumatic circuits
I. Troubleshooting

Total Lecture Hours —

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

Upon successful completion of this course the student will be able to:

A. **IDENTIFY AND EXPLAIN THE THEORY AND USE OF MAJOR SYSTEMS THAT COMPRISE A HYDRAULIC OR PNEUMATIC SYSTEM SUCH AS PUMPS, TANKS, PLUMBING, FLUID, ROTARY ACTUATORS, LINEAR ACTUATORS, FLOW CONTROL VALVES, PRESSURE CONTROL VALVES, DIRECTIONAL CONTROL VALVES, PILOT-OPERATED HYDRAULIC AND PNEUMATIC COMPONENTS, AND SOLENOID OPERATED HYDRAULIC AND PNEUMATIC COMPONENTS**
    1. Identify the Following Subsystems of a Hydraulic System:
        a. Fixed and variable displacement pumps

1) Gear pumps
2) Vane pumps
3) Gearotor pumps
4) Piston pumps

b. Centrifugal pumps
c. Fluid reservoir (tank)
d. Fluid
   1) Viscosity
   2) Fluid conditioning (filtration)
e. Fluid lines
   1) Working lines
   2) Pilot lines
   3) Drain lines
f. Actuators
   1) Linear actuators (cylinders, all types)
   2) Rotary actuators (vane and piston motors, fixed displacement and variable displacement)
g. Flow control valves
h. Valve actuators
i. Pressure control valves
   1) Pressure relief
   2) Pressure reducing
   3) Sequence valves
j. Check valves
k. Directional control valves
l. Pilot operation of valves
m. Solenoid operation of valves
n. Accumulators
o. Pressure and temperature compensation
p. Manifolds

2. Identify the Following Subsystems of a Pneumatic System:
   a. Compressors
      1) Piston compressors
      2) Rotary screw compressors
      3) Turbine compressors
   b. Air receiver (tank)
   c. De-humidifier
   d. Air conditioners
      1) Separators
      2) Filters
      3) Lubricators
   e. Air lines
      1) Working lines
      2) Pilot lines
      3) Exhaust lines
   f. Actuators
      1) Linear actuators (cylinders, all types)
      2) Rotary actuators (air motors)

    - g. Flow control valves
    - h. Valve actuators
    - i. Pressure control valves
        - 1) Pressure relief
        - 2) Pressure reducing
        - 3) Sequence valves
    - j. Check valves
    - k. Directional control valves
    - l. Pilot operation of valves
    - m. Solenoid operation of valves
    - n. Accumulators
    - o. Pressure and temperature compensation
    - p. Manifolds
- 3. Explain the Theory of Operation, the Purpose of Each, and Variations on the above Subsystems

B. APPLY FORMULAS AND MATHEMATICS TO CALCULATE FORCE, PRESSURE, VOLUME, HORSEPOWER, ROD SPEED FOR LINEAR ACTUATORS, ROTATIONAL SPEED FOR ROTARY ACTUATORS, PUMPING RATES FOR PUMPS, AND PRESSURES IN VARIOUS SCALES; FOR BOTH HYDRAULIC AND PNEUMATIC SYSTEMS

- 1. Given Pressure, Surface Area, or Force Will Calculate Each of the Following:
    - a. Force
    - b. Surface area
    - c. Pressure
- 2. Given Pump Displacement, Motor Displacement, or Piston Diameter and Stroke Will Calculate Volume of Fluid per Unit of Time Gallons per Minute (GPM), Cubic Feet per Minute (CFM) or Liters per Minute (LPM)
- 3. Given Flow and Pressure Will Calculate the Horsepower or Mechanical Watts of Power Generated in the System or Subsystem
- 4. Given Flow Rate, Piston Diameter, and Stroke, Will Calculate Rod Speed for Linear Hydraulic Actuators
- 5. Given Flow Rate and Displacement, Will Calculate Rotational Speed for Hydraulic Motors
- 6. Given Displacement and Rotational Speed, Will Calculate Flow Rate for Various Types of Hydraulic Pumps
- 7. Given Volumetric Displacement and Rotational Speed, Will Calculate Through-put for Compressors and Vacuum Pumps
- 8. Use Pressure in a Given Scale, and Convert it to the Following Pressure Scales:
    - a. Kilopascals (Kpa)
    - b. Pounds per square inch gage (PSIG)
    - c. Pounds per square inch absolute (PSIA)
    - d. Pounds per square inch vacuum (PSIV)
    - e. Bar
    - f. Inches of mercury (in Hg)
    - g. Inches of water (in H_2O)
    - h. Inches of mercury (vacuum scale in Hg)
    - i. Torr
    - j. Micron

C. USE MEASURING INSTRUMENTS SUCH AS FLOW METERS, TEMPERATURE GAUGES, FLOW CONTROL VALVES, U-TUBE MANOMETERS, AND PRESSURE GAUGES, TO MEASURE FLOWS, PRESSURES, AND THE OPERATING CONDITION OF THE FLUID POWER SYSTEM

D. USE HYDRAULIC LINES AND A HYDRAULIC SYSTEM TO EXPLAIN THE CONCEPT OF VISCOSITY, ITS METHODS OF MEASUREMENT, AND DEMONSTRATE THE EFFECTS OF OIL VISCOSITY UPON PRESSURE DROPS IN THE SYSTEM

E. USE A PNEUMATIC AND A HYDRAULIC SYSTEM TO DEMONSTRATE THE EFFECTS OF PRESSURE UPON THE VOLUME OF FLUID OR AIR IN THE SYSTEM

F. USE A PNEUMATIC AND A HYDRAULIC SYSTEM TO DEMONSTRATE THE EFFECTS OF SYSTEM PRESSURE UPON ACTUATOR SPEED

G. USE A PNEUMATIC AND A HYDRAULIC SYSTEM TO DEMONSTRATE THE EFFECTS OF SYSTEM FLOW UPON ACTUATOR SPEED

H. MEASURE PRESSURE DROPS AS A FUNCTION OF FLOW, THE METHODS OF DIVERTING FLOW, AND THE LEAKAGE RATE OF HYDRAULIC DIRECTIONAL CONTROL VALVES

1. Use Flow Meters and Pressure Gages to Demonstrate the Relationship Between Flow and Pressure
2. Use Flow Meters, Pressure Gages and a Pressure Relief Valve to Demonstrate the Diversion of Flow When Regulating Pressure
3. Use Flow Meters and Pressure Gages to Demonstrate the Leakage Rate of Directional Control Valves as a Function of Pressure

I. MEASURE THE CRACKING PRESSURE AND OPERATING CHARACTERISTICS OF PRESSURE CONTROL VALVES

J. USE A HYDRAULIC SYSTEM TO DEMONSTRATE THE FUNCTION AND OPERATING CHARACTERISTICS OF HYDRAULIC ACCUMULATORS

K. USE A PNEUMATIC AND A HYDRAULIC SYSTEM TO CONNECT, MEASURE, AND DEMONSTRATE THE OPERATING CHARACTERISTICS OF A REGENERATIVE CIRCUIT, AN INTENSIFIER CIRCUIT, A COUNTER BALANCE CIRCUIT, A SEQUENCING CIRCUIT, AN UNLOADING ACCUMULATOR CIRCUIT, AN ACCUMULATOR EMERGENCY POWER CIRCUIT, A VENTURI CIRCUIT, AIR BEARINGS, AND ELECTRICAL CONTROL OF HYDRAULIC AND PNEUMATIC CIRCUITS

1. Connect Hydraulic or Pneumatic Components to Construct the Following Circuits:
    - a. Regenerative circuit
    - b. Intensifier circuit
    - c. Counter balance circuit
    - d. Sequencing circuit
    - e. Unloading accumulator circuit
    - f. Accumulator emergency power circuit
    - g. Air bearings
    - h. Venturi siphon
    - i. Electrical solenoid control of flows and pressures
    - j. Servo valve control of flows and pressures

2. Connect Flow Meters and Pressure Gages to the above Circuits to Demonstrate Their Operating Principles

L. USE A PNEUMATIC AND A HYDRAULIC SYSTEM TO DEMONSTRATE THE PROPER INSTRUMENTS AND TROUBLESHOOTING METHODS FOR FLUID POWER CIRCUITS

1. Connect a Flow Meter, Pressure Gage, Flow Control Valve, and Temperature Gage to Serve as a Test Apparatus
2. Demonstrate the Proper Methods for Using the above Setup to Test Hydraulic or Pneumatic Systems

COURSE OBJECTIVES: SCANS COMPETENCIES

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The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. ***Resources:*** *Identifies, organizes, plans, and allocates resources*
   1. allocates time
      a. completes assigned work on time
      b. successfully completes timed examinations

B. ***Interpersonal:*** ***Works with others***
   1. participates as a member of a team
      a. participates in team math problem solving
      b. participates in study groups
   2. teaches others
      a. helps team members solve troubleshooting problems
      b. contributes information to teams/study groups
   3. satisfies instructor assigned requirements
   4. exercises leadership
      a. forms study groups
      b. motivates teams/study groups to succeed
      c. expresses ideas, feelings, and opinions clearly
      d. identifies whether the source of a position is an idea, feeling, or opinion
      e. provides supporting facts to support positions
   5. expresses ideas and listens to others to solve team problems
   6. works well with team and class members regardless of race class, ethnicity, or religion

C. ***Information:*** *Acquires and uses information*

1. acquires and evaluates Information
   a. obtains new or complementary information for various sources such as:
      1) text books
      2) lectures
      3) library
      4) periodicals
      5) internet
   b. evaluates information for accuracy, challenges information that contradicts logical evaluation
2. keeps and maintains an organized class lab workbook
3. gives oral/written presentations to class concerning lab findings
4. use computers to simulate the operation of hydraulic components/circuits

D. Systems: Understands complex inter-relationships

1. understands systems
   a. understands hydraulic/pneumatic systems
   b. understands how component works in circuit
2. monitors and corrects performance
   a. evaluate hydraulic/pneumatic systems using mathematics and physics
   b. corrects systems performance from results of evaluation
3. finds alternate methods to accomplish hydraulic/pneumatic functions

E. Technology: Works with a variety of technologies

1. selects appropriate technology
   a. selects appropriate hydraulic or pneumatic circuit to accomplish task
   b. interfaces hydraulic or pneumatic valves with electrical controls
2. uses hydraulic test/instrumentation to monitor circuits
3. if hydraulic or pneumatic circuit does not function properly, finds problem

II. FOUNDATION SKILLS

***A. Basic Skills:** Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*

1. ***Reading:** Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
   a. reads assigned course material
   b. interprets reading material to perform successfully in class
   c. interprets table and graphical data from lab data
2. ***Writing:** Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
   a. writes lab reports
   b. creates graphical charts from lab data
3. ***Arithmetic/Mathematics:** Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
   a. performs mathematical computations using scientific and engineering notation

        b. applies the principles of plane geometry, solid geometry, and algebra to solve technical fluid power problems
    4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
        a. actively listens to the information being presented in class and feeds back concepts
        b. listens to the ideas, feelings, and opinions of fellow classmates
    5. ***Speaking:*** *Organizes ideas and communicates orally*
        a. presents ideas and information in class
        b. contributes to classroom discussion.

B. ***Thinking Skills:*** *Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*
    1. ***Creative Thinking:*** *Generates new ideas*
        a. solves instructor provided mental troubleshooting exercises
        b. constructs electro-hydraulic or electro-pneumatic circuits to accomplish instructor provided tasks
    2. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
        a. chooses proper size fluid power component for proposed task
        b. determines range of system capability from parameters of components and purpose of system
    3. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
        a. determines cause of malfunction in complex fluid power circuit and chooses proper repair procedure
    4. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
        a. relates hydraulic or pneumatic symbology to actual component parts of system
        b. interprets graphical data to determine limits of component operation
    5. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
        a. uses effective study techniques to acquire new class material
        b. practices to acquire new skills
    6. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
        a. applies the concepts of physics to understand the transmission of power through a fluid power system

C. ***Personal Qualities:*** *Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*
    1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
        a. performs at or above expected class level
        b. sets individual/group goals and accomplishes them
    2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
        a. contributes to classroom discussion with original ideas

    - b. maintains a positive sense of humor that is not at the expense of another person's sense of self worth

3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    - a. allows divergent views in class discussions
    - b. responds positively to new ideas
    - c. supports the worthwhile goals and objectives of the team and fellow classmates

4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    - a. accepts responsibility for completion of assigned work
    - b. sets individual/group goals and accomplishes them
    - c. maintains a record of accomplishments

5. ***Integrity/Honesty:*** *Chooses ethical courses of action*
    - a. performs own work when required, does not plagiarize the work of others
    - b. protects school property
    - c. does not misappropriate the property of the school or other classmates
    - d. reports infractions of school rules to school authorities

Appropriate Reference Materials:

1. Fluid Power by Vickers Inc.

AET210.WPD
05/062896

Machine Tool Advanced Skills
Technology Program

MAST

COURSE SYLLABUS

PROGRAMMABLE LOGIC CONTROLLERS

MAST PROGRAM
COURSE SYLLABUS
PROGRAMMABLE LOGIC CONTROLLERS

Lecture hours/week: 2 **Lab hours/week: 3** **Credit hours: 3**

COURSE DESCRIPTION:

The study of concepts associated with the operation, construction, interfacing, and programming of programmable logic controllers. The student will explore the relationship between symbolic reasoning using Boolean concepts and the solution of control problems in modern industrial equipment. In addition, the student will conduct experiments with digital circuits to understand digital logic concepts. This course includes hands-on laboratory experiences in constructing, operating, configuring, and programming programmable logic controllers. (FT) Associate Degree Credit

PREREQUISITES: **Industrial Programming Theory and Industrial Electronics/Electricity, each with a grade of "C" or better, or equivalent**

COURSE OBJECTIVES:

Upon successful completion of this course, the student will:

1. Define the symbology and proper operation of the following: and, or, nand, nor, digital inversion, exclusive or, exclusive nor, flip/flops, counters, registers, memories
2. Correctly solve basic logic problems using Boolean algebra, De Morgan's Theorems
3. Use a multimeter or oscilloscope to test and troubleshoot digital circuits
4. Develop a Boolean solution to a basic logic problem, express the solution to the problem in digital logic, and convert the digital logic solution to a ladder diagram
5. Properly connect a computer to the communications port of the programmable logic controller and configure and program the controller
6. Use ladder programming, Boolean programming, statement list programming, or other types of programming languages suitable for use with a programmable logic controller, and a hand-held programming unit, or a computer, and program the controller with a control solution
7. Properly interface a programmable logic controller's control modules to digital and analog devices and control those devices

REQUIRED COURSE MATERIALS:

Textbook: An example of a text which would be appropriate for this course is: Programmable Controllers-Theory and Implementation by Bryan, 1991

Lab Materials: Students will be required to purchase the following supplies:

1) Paper, notebooks and writing instruments
2) Safety glasses

3) Scientific calculator
4) Scantron examination sheets

METHODS OF INSTRUCTION:

Lecture:	Presentations will include lecture, demonstration, and group problem solving.
Laboratory:	Laboratory will be a "hands-on" exploration and problem solving.
Group Projects:	Group projects will be assigned during the lab periods. Each set of projects will provide practice in one or more concepts. The students will work on problems that are derived from manufacturing or industrial situations. Any problems not solved by the team will be assigned as homework problems. The individual grade for these tasks will be a combination of a team grade, and a team assessment of the individual's contribution to the team's efforts. The instructor will devise a method whereby the team's assessment of an individual's contributions is fair and free of bias.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. perform on written or oral examinations
2. perform on outside assignments
3. contribute to group problem solving
4. apply theory to problem solving
5. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Logic Symbology and Devices		
A. Integrated circuits		
B. Logic families		
C. Waveform measurement		
D. Gates		
E. Combinational logic		
F. Latches, flip/flops		
G. Counters		
H. Registers		
I. Memories		
Microprocessor Controller Troubleshooting		
A. Elements of a microprocessor		
B. Testing a microprocessor controlled system		

Introduction to Programmable Logic Controllers

- A. Basic components of a PLC system
- B. Inputs, outputs, processing

PLC Programming Languages

- A. Boolean programming
- B. Ladder programming
- C. Statement list programming
- D. Flow chart programming

PLC Digital I/O

- A. Digital I/O
- B. Analog I/O
- C. Motion control
- D. Miscellaneous I/O —

Total Lecture Hours

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

Upon successful completion of this course the student will be able to:

- **A. DEFINE THE SYMBOLOGY AND PROPER OPERATION OF THE FOLLOWING: AND, OR, NAND, NOR, DIGITAL INVERSION, EXCLUSIVE OR, EXCLUSIVE NOR, FLIP/FLOPS, COUNTERS, REGISTERS, MEMORIES**
  - 1. Define the Basic Symbols Used to Represent the Following Logical Functions:
    - a. AND
    - b. OR
    - c. NOT
    - d. XOR
    - e. NAND
    - f. NOR
    - g. NOT XOR
    - h. D latch flip/flops
  - 2. Combine Symbols to Produce the Following Logical Functions:
    - a. Counters
    - b. Registers
    - c. 8 bit memories (byte)
  - 3. Explain the Operation of the above Logical Devices and Functions
- **B. CORRECTLY SOLVE BASIC LOGIC PROBLEMS USING BOOLEAN ALGEBRA, AND DE MORGAN'S THEOREM**
- **C. USE A MULTIMETER OR OSCILLOSCOPE TO TEST AND TROUBLESHOOT DIGITAL LOGIC CIRCUITS**
- **D. DEVELOP A BOOLEAN SOLUTION TO A BASIC LOGIC PROBLEM, EXPRESS THE SOLUTION TO THE PROBLEM IN DIGITAL LOGIC, AND CONVERT THE DIGITAL LOGIC SOLUTION TO A LADDER DIAGRAM**
  - 1. Express a Control Problem as a Boolean Statement
  - 2. Convert the Boolean Statement into Digital Symbolic Logic

3. Convert the Boolean Statement or the Digital Symbolic Logic into a Ladder Logic Diagram

E. PROPERLY CONNECT A COMPUTER TO THE COMMUNICATIONS PORT OF THE PROGRAMMABLE LOGIC CONTROLLER, AND CONFIGURE AND PROGRAM THE CONTROLLER

1. Connect an RS-232 Interface from a Personal Computer (PC) to the Communications Port of a Programmable Logic Controller
2. Load the Programming Software into the PC
3. Configure the Programming Software to Communicate with the Programmable Logic Controller
4. Use the PC and Programming Software to Configure and Program the Programmable Logic Controller

F. USE LADDER PROGRAMMING, BOOLEAN PROGRAMMING, STATEMENT LIST PROGRAMMING, OR OTHER TYPES OF PROGRAMMING LANGUAGES SUITABLE FOR USE WITH A PROGRAMMABLE LOGIC CONTROLLER, AND A HAND-HELD PROGRAMMING UNIT, OR A COMPUTER, AND PROGRAM THE CONTROLLER WITH A CONTROL SOLUTION

1. Write a Control Solution Using One or More of the Following Symbolic Programming Languages:
    a. Ladder programming
    b. Statement list programming
    c. Flow diagram programming
    d. Boolean programming
2. Connect a Hand-Held Programming Unit or a Personal Computer to the Programmable Logic Controller (PLC)
3. Program the Control Solution Off Line and Then down Load the Program
4. Program the Control Solution On Line

G. PROPERLY INTERFACE A PROGRAMMABLE LOGIC CONTROLLER'S CONTROL MODULES TO DIGITAL AND ANALOG DEVICES, AND CONTROL THOSE DEVICES

1. Properly Wire the Following On/Off Input Devices to an Input Module of the Programmable Logic Controller:
    a. Switches
    b. On/off proximity sensors
    c. Relay contacts
    d. The output of a PLC output module
2. Properly Wire the Following On/off Output Devices to the Outputs of the PLC:
    a. Relays
    b. Hydraulic valve solenoids
    c. Pneumatic valve solenoids
    d. An input from the input module of the PLC
    e. The motor starter for an AC inductive motor
3. Use Multimeters to Test the Connections
4. Program the PLC to Operate Each of the Outputs Based upon the State of Each of the Inputs
5. Properly Wire the Following Analog Input Devices to an Analog Input Module of the Programmable Logic Controller:

    a. Potentiometer
    b. RTD
    c. Thermocouple
    d. Pressure sensor
    e. The analog output of a PLC analog output module:
6. Properly Wire the Following Analog Output Devices to an Analog Output Module of the Programmable Logic Controller:
    a. The 4-20 milliamp input of an AC power control module
    b. The speed control input to a DC motor control module
    c. A hydraulic servo valve or proportional control valve
    d. The analog input of a PLC analog input module
7. Use Multimeters and Oscilloscopes to Test the Connections
8. Program the PLC to Operate Each of the Outputs Based upon the State of Each of the Inputs
9. Use the Mathematical Algorithms of the PLC and the above Analog Inputs/outputs to Create/program a PID Control Loop

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

A. ***Resources:*** *Identifies, organizes, plans, and allocates resources*
  1. allocates time
      a. completes assigned work on time
      b. successfully completes timed examinations

B. ***Interpersonal:*** *Works with others*
  1. participates as a member of a team
      a. participates in team problem solving
      b. participates in team lab projects
      c. participates in study groups
  2. teaches others
      a. helps team members solve problems
      b. contributes information to teams/study groups
  3. satisfies instructor assigned requirements
  4. exercises leadership
      a. forms study groups
      b. motivates teams/study groups to succeed

        - c. expresses ideas, feelings, and opinions clearly
        - d. identifies whether the source of a position is an idea, feeling, or opinion
        - e. provides supporting facts to support positions
    - 5. expresses ideas and listens to others to solve team problems
    - 6. works well with team and class members regardless of race class, ethnicity, or religion
- C. ***Information:*** *Acquires and uses information*
    - 1. acquires and evaluates Information
        - a. obtains new or complementary information for various sources such as:
            - 1) text books
            - 2) lectures
            - 3) library
            - 4) periodicals
            - 5) internet
        - b. evaluates information for accuracy, challenges information that contradicts logical evaluation
    - 2. keeps and maintains an organized class lab workbook
    - 3. gives oral/written presentations to class
    - 4. uses computers to communicate and solve programming problems
- ***D.*** ***Systems:*** *Understands complex inter-relationships*
    - 1. understands systems
        - a. understands complex PLC control systems
        - b. understands control of processes in physical systems
    - 2. monitors and corrects performance
        - a. evaluates physical systems to detect malfunctions
        - b. corrects systems from results of evaluation
    - 3. finds alternate methods to solve control/interfacing problems
- ***E.*** ***Technology:*** *Works with a variety of technologies*
    - 1. selects technology:
        - a. applies the appropriate hardware to solve PLC control problems
        - b. understands the use of computers, PLCs, and associated hardware or software
    - 2. applies technology to task:
        - a. sets up and configures programming computers
        - b. connects communication interface
        - c. connects programming device to PLC and programs the PLC
    - 3. if equipment does not perform as expected, finds problem

II. FOUNDATION SKILLS

- ***A.*** ***Basic Skills:*** *Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*
    - **1.** ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
        - a. reads assigned course material
        - b. interprets reading material to perform successfully in class
        - c. interprets programming data from symbolic statements

2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    a. writes programs using structured programming
    b. maintains a lecture notebook
3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    a. performs mathematical computations using binary math
    b. writes control statements using Boolean algebra
    c. applies the principles of algebra to solve control problems
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
    a. actively listens to the information being presented in class and feeds back concepts
    b. listens to the ideas, feelings, and opinions of fellow classmates
5. ***Speaking:*** *Organizes ideas and communicates orally*
    a. presents ideas and information in class
    b. contributes to classroom discussion.

B. ***Thinking Skills:*** *Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. ***Creative Thinking:*** *Generates new ideas*
    a. uses Boolean algebra to create PLC control algorithms
    b. devises new interconnectivity for PLC control solutions
2. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. chooses the best control solution to solve a control problem
    b. uses logical symbology to determine methods of PLC control to cause alternate/desirable changes in physical systems
3. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    a. solves control problems in PLC systems
    b. troubleshoots system malfunctions
    c. determines proper course of action to repair problem
4. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. relates logical symbology to the solution of real world control problems
    b. visualizes module connectivity that will accomplish PLC control tasks
5. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. uses effective study techniques to acquire new class material
    b. practices to acquire new skills
6. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*

    a. uses rules and principles of binary mathematics, Boolean algebra, control of physical processes, and computer technology to create control solutions
    b. relates Boolean symbology to PLC ladder programming symbology

C. ***Personal Qualities:*** *Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    a. performs at or above expected class level
    b. sets individual/group goals and accomplishes them
2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    a. contributes to classroom discussion with original ideas
    b. maintains a positive sense of humor that is not at the expense of another person's sense of self worth
3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. allows divergent views in class discussions
    b. responds positively to new ideas
4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. accepts responsibility for completion of assigned work
    b. sets individual/group goals and accomplishes them
    c. maintains a record of accomplishments
5. ***Integrity/Honesty:*** *Chooses ethical courses of action*
    a. performs own work when required, does not plagiarize the work of others
    b. protects school property
    c. does not misappropriate the property of the school or other classmates
    d. reports infractions of school rules to school authorities

Appropriate Reference Materials:

1. Industrial Computing/Programmable Logic Controllers, Instrument Society of America (ISA) publication
2. Modern Industrial Electronics, Revised and Expanded Edition, (formerly Industrial Electronics and Robotics), by Schuler/MacNamee, 1992

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program

MAST

COURSE SYLLABUS

INDUSTRIAL MACHINE TECHNOLOGY

MAST PROGRAM
COURSE SYLLABUS
INDUSTRIAL MACHINE TECHNOLOGY

Lecture hours/week: 2 **Lab hours/week: 3** **Credit hours: 3**

COURSE DESCRIPTION:

A survey course designed to provide the student with an overview of typical machine shop operations and an introduction to welding technology. (FT) Associate Degree Credit

PREREQUISITES: **Satisfactory completion of Manufacturing Metrics and Calculations and Print Reading and Symbology, with a grade of "C" or better, or equivalent.**

COURSE OBJECTIVES:

Upon successful completion of this course, the student will:

1. Use measuring instruments such as micrometers, vernier calipers, depth gages, JO blocks, sine bars, and dial indicators, to set up machines, and machine parts to drawing specifications
2. Apply formulas found in the study of machining technology to calculate the spindle speeds and feed rates to be employed in cutting parts on lathes and mills
3. Use mills and lathes to machine a usable part to drawing specifications
4. Apply safety training to perform to standards on a written safety examination
5. Perform satisfactorily on a written examination that contains questions pertaining to robotics applications of welding technology such as TIG, MIG< and resistance welding

REQUIRED COURSE MATERIALS:

Textbook: An example of a text which would be appropriate for this course is: Technology of Machine Tools, by Krar/Oswald, 4th Edition, 1992

Lab Materials: Students will be required to purchase the following supplies:

1) Paper, notebooks and writing instruments
2) Protective lab apron, safety glasses
3) Scientific calculator
4) Scantron examination sheets
5) Cutting tool steel, raw stock

METHODS OF INSTRUCTION:

Lecture: Presentations will include lecture, demonstration, and group problem solving.

Laboratory: Laboratory will be "hands-on" fabrication of part.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. perform on written or oral examinations
2. perform on outside assignments
3. contribute to group problem solving
4. apply theory to problem solving
5. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Machine Shop Safety		
Measuring Instruments		
A. 0-1" O.D. micrometer		
B. 6" machinist scale		
C. 6" dial calipers		
D. Vernier calipers		
E. 0-1" dial indicator		
F. Depth micrometer		
Lathe Practice		
A. Indicate 3 and 4 jaw chucks		
B. Grinding cutting tool		
C. Turning operation, outside diameter		
D. Drilling operation		
E. Reaming operation		
F. Polishing operation		
Milling Machine		
A. Squaring work piece to machine		
B. Slot milling operation		
C. Drill and tap operations		
D. Deburring operations		
Welding Technology		
A. Arc welding		
B. Heliarc welding		
1) MIG welding		
2) TIG welding		
C. Resistance welding		
D. Induction welding		—
	Total Lecture Hours	

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

Upon successful completion of this course the student will be able to:

A. DEMONSTRATE SAFETY PRACTICES IN MACHINING ENVIRONMENT

1. Use Proper Safety Equipment
   - a. Identify safety equipment used in the machine environment
   - b. State effects of proper and improper safety equipment
   - c. Demonstrate proper use of common safety equipment
2. Identify Proper Clothing
   - a. Demonstrate proper dress for machining environment
   - b. State improper dress and its effects
3. State Proper Attitudes For Safety
   - a. Explain responsibility for oneself and others
   - b. State benefits of correct safety practices
   - c. Explain costs of poor safety practices
4. Handle Chemicals Properly
   - a. Interpret material safety data sheets "MSDS"
   - b. Describe proper storage and disposal of chemicals
   - c. Identify labeling used for chemicals
   - d. Explain special precautions for handling chemicals
   - e. Discuss OSHA's and E.P.A.'s impact on chemical handling
5. Identify Fire Hazards in Machining
   - a. Identify fire hazards in machining environment and how to eliminate
   - b. Identify classes of fire extinguisher
   - c. State methods of dealing with fires
6. Demonstrate Proper Personal Hygiene
   - a. Identify hygiene as a part of personal safety
   - b. State effect of oils, solvents, and coolants on the skin and eyes
   - c. Exhibit proper personal hygiene
7. Demonstrate Proper Laboratory Cleaning
   - a. Discuss the effects of a filthy work environment
   - b. State impact of unclean work area on safety, machine tool accuracy and machine tool fixtures
   - c. Exhibit proper cleaning of machine tools and accessories

B. USE MEASURING INSTRUMENTS AND THEIR ACCESSORIES

1. Identify Applications and Limitations of Measuring Instruments
   - a. Identify common measuring instruments and their applications
   - b. Identify limitations of each measuring instrument
   - c. Explain and demonstrate methods of measuring instrument calibration
   - d. Demonstrate proper handling of measuring instruments
2. Demonstrate Use of Measuring Instruments
   - a. Rulers (scales)
   - b. Outside micrometers
   - c. Vernier calipers
   - d. Dial calipers
   - e. Depth micrometers
   - f. Inside micrometers
   - g. Telescoping gauges
   - h. Edge finders
     - 1) Test and dial indicators
     - 2) Gauge blocks

                3) Coordinate measuring machine (CMM)
        i. Height gauges
        j. Protractors
        k. Bore gauges

C. **APPLY FORMULAS FOUND IN THE STUDY OF MACHINING TECHNOLOGY, TO CALCULATE THE SPINDLE SPEEDS AND FEED RATES TO BE EMPLOYED IN CUTTING PARTS ON LATHES AND MILLS**

1. Perform RPM Calculations
    a. Explain the need to properly calculate RPMs
    b. Describe implications of changing variables in formulas
    c. Explain effect of different alloys and cutting tools on RPMs
    d. Demonstrate correct use of formulas to achieve proper RPM
2. Perform Feed Calculations
    a. State the need for proper feed calculations
    b. Explain the meaning of each variable in feed equations
    c. Explain position and negative effects of RPM, feed, and depth of cut on tool life, production and profitability
    d. List benefits of increased production related to increased profit
    e. State differences between inch per revolution (IPR) and inch per minute (IPM)
    f. State proper application of IPR and IPM
    g. Explain chip load per tooth for roughing versus finishing of different materials
    h. Explain effects of set-up rigidly, tool diameter, length and horse power on feed
    i. Explain step over differences in milling
    j. Establish proper roughing and finishing feed rates for:
        1) Face milling
        2) Slot milling
        3) Drilling
        4) Reaming
        5) Tapping
        6) Turning
        7) Boring
        8) Single point turning
        9) Facing
6. Perform Depth of Cut Calculations
    a. State depth of cut calculations
    b. Demonstrate ability to calculate RPM, feed and depth of cut
7. Perform Thread Cutting Calculations
    a. State uses of thread calculations
    b. Describe equations to identify thread depth and measure thread sizes
8. Perform Tap Drill Calculations
    a. State uses of tap drill calculations
    b. Explain tap size versus drill sizes
    c. Describe equation to calculate tap drill sizes for fractional taps
    d. List equation converting tap size number to decimal
    e. Demonstrate use of tap drill calculations

9. Interpret Reference Tables Related to Machining
    a. Identify commonly used reference tables
    b. Locate specific reference tables in various support documentation
    c. Extract and apply reference information

D. DEMONSTRATE CUTTING TOOL IDENTIFICATION AND APPLICATION

1. Identify Cutting Tools and Describe Tool Nomenclature
    a. Identify different types of end mills, center drills, drills, reamers, taps
    b. Explain cost differences for types of tooling within same tool classification, including:
        1) End mills
        2) Face mills
        3) Center drills
        4) Drills
        5) Reamers
        6) Single point boring head
        7) Single point threading tools
        8) Counter boring tools
        9) Spot facing tools
        10) Taps
2. Identify and Explain Application of Machine Tools
    a. List different applications requiring proper selections of each tool
    b. Identify proper cutting tool for specified application
    c. Demonstrate ability to identify cutting tools defined by blueprint, process documentation and verbal instruction
    d. Demonstrate ability to give written or verbal justification of tool selection to include cost differential

E. IDENTIFY AND DESCRIBE MACHINE OPERATION NOMENCLATURE

1. Identify and Describe Types of Milling
    a. Explain climb milling
    b. Explain conventional milling
    c. Describe benefits and drawbacks of each application
    d. Explain contouring operations
    e. Explain pocketing operations
2. Describe Drilling/Boring Operations and Their Applications
    a. Describe applications for center drilling
    b. List and explain the different accuracies achieved from drilling, reaming and single point boring
    c. List and explain the reasons for single point boring
    d. Describe the difference between spot facing and counter boring operations
3. Identify and Describe Threading Operations
    a. Identify and describe common single point threading tool set-ups
    b. Describe the reasons for using single point threading tools instead of taps and dies
    c. Identify and describe various tapping operations and accessories

F. USE MILLS AND LATHES TO MACHINE A USABLE PART TO DRAWING SPECIFICATIONS

G. EXPLAIN ROBOTICS APPLICATIONS OF WELDING TECHNOLOGY SUCH AS TIG, MIG, AND RESISTANCE WELDING

1. Explain the Purpose of Inert Gas Welding, and the Differences Between Metal Inert Gas Welding (MIG) and Tungsten Inert Gas Welding (TIG)
    a. Identify gases used for MIG and TIG welding
    b. Explain the purpose of electrodes and types of electrodes
    c. Explain the purpose of wire feed
    d. Explain the function of arc voltage and arc current control
    e. Explain the difference between straight polarity welding and reverse polarity welding
    f. Explain the function of high frequency start
    g. Explain the function of pre flow and post flow
    h. Explain the difference between DC and AC gas welding
    i. Explain the theory behind inert gas welding
    j. Describe robotic applications of inert gas welding
2. Explain the Use and Applications of Resistance Welding
    a. Identify the parts of a resistance welder
    b. Explain the purpose of squeeze pressure and forge pressure
    c. Explain the function and purpose of heat cycles and percentage of heat
    d. Explain the theory of resistance welding
    e. Describe robotic applications of resistance welding

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

- *A. Resources: Identifies, organizes, plans, and allocates resources*
    1. allocates time
        a. completes assigned work on time
    2. allocates money
        a. determines cost of materials and labor
    3. allocates resources
        a. completes stock request form for material
- *B. Interpersonal: Works with others*
    1. participates as a member of a team
        a. participates in study groups
    2. teaches others
        a. helps peers solve machining problems
    3. satisfies instructor assigned requirements

4. exercises leadership
    a. forms study groups
    b. motivates teams/study groups to succeed
    c. expresses ideas, feelings, and opinions clearly
    d. identifies whether the source of a position is an idea, feeling, or opinion
    e. provides supporting facts to support positions
5. expresses ideas and listens to others to solve problems
6. works well with team and class members regardless of race class, ethnicity, or religion

C. Information: Acquires and uses information

1. acquires and evaluates Information
    a. obtains new or complementary information for various sources such as:
        1) text books
        2) lectures
        3) library
        4) periodicals
        5) internet
    b. evaluates information for accuracy, challenges information that contradicts logical evaluation
2. keeps and maintains an organized class note/workbook
3. gives oral/written presentations to class
4. uses computers to solve math problems

D. Systems: Understands complex inter-relationships

1. understands systems
    a. understands systems of machine operations

E. Technology: Works with a variety of technologies

1. selects technology
    a. selects the appropriate tools to measure/solve problems
2. sets up machines to manufacture parts
3. if part does not measure according to specifications, finds problem

II. FOUNDATION SKILLS

A. Basic Skills: *Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*

1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
    a. reads assigned course material
    b. interprets reading material to perform successfully in class
    c. interprets graphical data from Cartesian coordinate graphs
2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
    a. uses written English to plan fabrication process
    b. maintains a lecture notebook

3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
    a. performs mathematical computations using scientific notation
    b. performs mathematical computations using engineering notation
    c. applies the principles of plane geometry to solve technical problems
    d. applies the principles of solid geometry to solve technical problems
    e. applies the principles of trigonometry to solve technical problems
    f. applies algebra to understand physical systems, and solve technical problems
4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
    a. actively listens to the information being presented in class and feeds back concepts
    b. listens to the ideas, feelings, and opinions of fellow classmates
5. ***Speaking:*** *Organizes ideas and communicates orally*
    a. presents ideas and information in class
    b. contributes to classroom discussion.

B. ***Thinking Skills:*** *Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*

1. ***Creative Thinking:*** *Generates new ideas*
    a. uses formulas and algebraic mathematics to create new relationships
2. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. uses measurements to predict the limits of machining operations
3. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    a. measures process, and makes fabrication decisions
4. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. uses drawings to create fabricated part
5. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. uses effective study techniques to acquire new class material
    b. practices to acquire new skills
6. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. uses rules and principles of machining to create products

C. ***Personal Qualities:*** *Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    a. performs at or above expected class level
    b. sets individual/group goals and accomplishes them
2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    a. contributes to classroom discussion with original ideas

    b. maintains a positive sense of humor that is not at the expense of another person's sense of self worth

3. ***Sociability:** Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. allows divergent views in class discussions
    b. responds positively to new ideas
    c. supports the worthwhile goals and objectives of the team and fellow classmates
4. ***Self-Management:** Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. accepts responsibility for completion of assigned work
    b. sets individual/group goals and accomplishes them
    c. maintains a record of accomplishments
5. ***Integrity/Honesty:** Chooses ethical courses of action*
    a. performs own work when required, does not plagiarize the work of others
    b. protects school property
    c. does not misappropriate the property of the school or other classmates
    d. reports infractions of school rules to school authorities

Appropriate Reference Materials:

1. Machine Tools - Processes and Applications, 2nd Edition by Genevro/Stephen, 1994

*M*achine Tool *A*dvanced *S*kills
*T*echnology Program
MAST

COURSE SYLLABUS

FLEXIBLE MANUFACTURING SYSTEMS/ROBOTICS

MAST PROGRAM
COURSE SYLLABUS
FLEXIBLE MANUFACTURING SYSTEMS/ROBOTICS

Lecture hours/week: 2 **Lab hours/week: 6** **Credit hours: 4**

COURSE DESCRIPTION:

This course covers the design, installation, operation, and maintenance of a Flexible Manufacturing system. In addition, the role of robots and work centers in Flexible Manufacturing along with the theory and programming of these robots and work centers is included. Laboratory will include the assembly, interfacing, troubleshooting, and repair of various automated equipment and robots during the construction of a flexible manufacturing cell. (FT) Associate Degree Credit

PREREQUISITES: **Satisfactory completion of Motion Control/Servo Systems, Fluid Power Technology, and Programmable Logic Controllers, each with a grade of "C" or better, or equivalent**

COURSE OBJECTIVES:

Upon successful completion of this course, the student will:

1. Use an IBM compatible computer and an industrial robot to connect a RS-232-C communications interface to provide communications between the robot and a computer
2. Use a teach pendant, tooling and an industrial robot to reach the robot to perform a complex function
3. Use an IBM compatible computer and an industrial robot to create, load, and run a pelletizing program in the robot
4. Interface a programmable logic controller and an industrial robot to provide on/off and serial digital communication between the two systems
5. Calibrate an industrial robot, using tools and measuring instruments by adjusting the home position of the robot
6. Use measuring instruments such as oscilloscopes, and tools to adjust the servo response of a CNC machine and an industrial robot
7. Adjust the speed and slow down cushions of a bang-bang pick and place pneumatic robot
8. Operate the types of automated equipment associated with flexible manufacturing systems
9. Assemble, interface, troubleshoot, maintain, and repair a flexible manufacturing system

REQUIRED COURSE MATERIALS:

Textbook: An example of a text which would be appropriate for this course is: Modern Industrial Electronics, Revised and Expanded Edition, by Schuler/MacNamee, 1992 (formerly, Industrial Electronics and Robotics by Schuler/McNamee, 1987)

Lab Materials: Students will be required to purchase the following supplies:

1) Paper, notebooks and writing instruments

2) Safety glasses
3) Scientific calculator, Scantron examination sheets

METHODS OF INSTRUCTION:

Lecture: Presentations will include lecture, video, and group problem solving.

Laboratory: Laboratory will be "hands-on" construction and problem solving.

Group Projects: Group projects will be assigned during the lab periods. Each set of projects will provide practice in one or more concepts. The students will work on problems that are derived from manufacturing or industrial situations. Any problems not solved by the team will be assigned as homework problems. The individual grade for these tasks will be a combination of a team grade, and a team assessment of the individual's contribution to the team's efforts. The instructor will devise a method whereby the team's assessment of an individual's contributions is fair and free of bias.

Method of Evaluation: A student's grade will be based on multiple measures of performance. The assessment will measure development of independent critical thinking skills and will include evaluation of the student's ability to:

1. perform on written or oral examinations
2. perform on outside assignments
3. contribute to group problem solving
4. apply theory to problem solving
5. maintain attendance per current policy

LECTURE OUTLINE:

Lecture Topics	Text Reference Page	Contact Hrs.
Introduction		
A. Definition of Flexible Manufacturing Systems		
B. History of Flexible Manufacturing Systems		
C. Economics of flexible manufacturing		
D. Future applications of flexible manufacturing		
E. Terminology		
Components of a Flexible Manufacturing Cell		
A. Work stations		
B. Robots		
C. Materials handling system		
D. Automated storage/retrieval		

system
E. Supervisory computer system

Types of Data Communication

A. Digital Input/Outputs
B. Dedicated Data Lines
C. Local Area Networks

Programmable Logic Controllers

A. PLC functions
B. Programming
C. Interfacing
D. Purpose of a PLC for a FMS cell

Supervisor Computers

A. Purpose of supervisory computers in FMS
B. Types of computers used in FMS
C. Examples of cell control software

Robot Functions in a FMS Cell

A. Robot terminology
B. Robot operation
C. Robot programming
D. Robot troubleshooting and adjustments

Flexible Manufacturing as a Part of Computer Integrated Manufacturing —

Total Lecture Hours

COURSE OBJECTIVES: TECHNICAL COMPETENCIES

Upon successful completion of this course the student will be able to:

A. USE A TEACH PENDANT, TOOLING AND AN INDUSTRIAL ROBOT TO TEACH THE ROBOT TO PERFORM A COMPLEX FUNCTION

1. Operate the Teach Pendent of an Industrial Robot
2. Set up Simulated Tooling to Provide the Accuracy Required for an Instructor Assigned Task
3. Teach the Robot to Perform a Complex Function Within the Tooling Limitations

B. USE AN IBM COMPATIBLE COMPUTER AND AN INDUSTRIAL ROBOT TO CREATE, LOAD, AND RUN A PELLETIZING PROGRAM IN THE ROBOT

1. Use a Personal Computer, to Connect Communications Cables to the Computers RS-232 Communications Ports
    a. Install serial cable for communication from a computer to a robot
    b. Configure the communications interface and make it function properly
2. Use a Robot Programming Language to Program a Control Task
    a. Use the proper procedures to accomplish structured programming
    b. Draw a flow chart or programming plan
    c. Comment the program properly
    d. Program the control task

    3. Down Load the Program and Run it
    4. Debug Programming/Control Problems

C. **INTERFACE PROGRAMMABLE LOGIC CONTROLLERS, COMPUTERS, AND AN INDUSTRIAL ROBOT TO PROVIDE ON/OFF AND SERIAL DIGITAL COMMUNICATION BETWEEN THE SYSTEMS**

    1. Use a Personal Computer to Connect Communications Cables to the Computers RS-232 Communications Ports
        a. Install serial cable for communication from a computer to a robot or CNC machine
        b. Configure the communications interface and make it function properly
    2. Properly Connect a Computer to the Communications Port of the Programmable Logic Controller, and Configure and Control the Controller
        a. Connect an RS-232 interface from a personal computer (PC) to the communications port of a programmable logic controller
        b. Load the control software into the PC
        c. Configure the control software to communicate with the programmable logic controller
        d. Use the PC and programming software to control the programmable logic controller
    3. Properly Wire the Output of a PLC Output Module to an Input Module of Another Programmable Logic Controller
    4. Properly Wire the Input from the Input Module of a PLC to the Outputs of the Another PLC
    5. Use Multimeters to Test the Connections
    6. Program One or More PLCs to Operate Each of the Outputs Based upon the State of Each of the Inputs from Another PLC

D. **CALIBRATE AND ALIGN INDUSTRIAL ROBOTS TO A WORK CELL, USING TOOLS AND MEASURING INSTRUMENTS**

    1. Adjust the Speed, Slow Down Cushions, and Mechanical Stops of a Bang-bang, Pick and Place Pneumatic Robot
    2. Apply Measurement Instruments Such As:
        a. Machinist squares
        b. Micrometers (inside and outside)
        c. Machinist levels
        d. Dial indicators
        e. Jo blocks
        f. Inclinometer
    3. Apply Principles of Machine Tool Metrology To:
        a. Level robot and work area
        b. Square robot to work area
    4. Demonstrate Lock-Out/Tag-Out Procedures
    5. Safely Assemble or Disassemble Fittings to Move/Align Mechanical Fixtures
    6. Safely Adjust Mechanical Features of Fittings to Align Work Cell/Robot

E. **OPERATE THE TYPES OF AUTOMATED EQUIPMENT ASSOCIATED WITH FLEXIBLE MANUFACTURING SYSTEMS**

    1. Explain the Safety Procedures in Effect When Activating or Moving Any Piece of Automated Equipment

2. Demonstrate the Safety Procedures Used When Entering the Work Envelope of an Industrial Robot
3. Demonstrate the Safety Procedures Used When Two or More People Are Working in the Same Cell
4. Operate Cell Control Computers
5. Use a Teach Pendent to Move an Industrial Robot
6. Manually Operate an Industrial CNC Machine
7. Initialize the Cell and Start Automatic Operations
8. Demonstrate the Safety Procedures Used When Starting Automatic Processes

F. PROGRAM THE DIFFERENT TYPES OF CONTROL SYSTEMS FOR COORDINATED OPERATION

1. Program the Control Systems to Produce Communications with the Following:
    a. Robot to PLC
    b. Robot to cell control computer
    c. PLC to cell control computer
    d. PLC to PLC via network
    e. PLC to PLC via input/output modules
2. Program the Computer, PLC and Robot Control Systems To:
    a. Coordinate the sequence of operations
    b. Prevent collisions
    c. Provide fail-safe operation
    d. Provide personnel safety

G. ASSEMBLE, INTERFACE, TROUBLESHOOT, MAINTAIN, AND REPAIR A FLEXIBLE MANUFACTURING SYSTEM

1. Safely Assemble Mechanical Systems
    a. Use tools properly/safely
    b. Use drawings/manuals
    c. Apply proper techniques for mechanical assembly/disassembly
    d. Document assembly/disassembly
    e. Use proper safety procedures for mechanical assembly
2. Safely Adjust/Measure Mechanical Systems
    a. Use tools/measuring instruments properly/safely
    b. Use drawings/manuals
    c. Understand consequences of adjustment
    d. Document adjustment/measurement
3. Safely Assemble Hydraulic and Pneumatic Components Tubing, and Fittings
    a. Use tools properly/safely
    b. Use drawings/manuals
    c. Apply proper techniques for hydraulic or pneumatic assembly/disassembly
    d. Document assembly/disassembly
    e. Use proper safety procedures for hydraulic or pneumatic assembly
4. Safely Adjust/Measure Flow and Pressures
    a. Use tools/measuring instruments properly/safely
    b. Use drawings/manuals
    c. Understand consequences of adjustment
    d. Document adjustment/measurement
5. Safely Assemble Electrical Components, Wiring and Fittings
    a. Use tools properly/safely

        b. Use drawings/manuals
        c. Apply proper techniques for electrical assembly/disassembly
        d. Document assembly/disassembly
        e. Use proper safety procedures for electrical assembly
    6. Safely Adjust/Measure Electrical Components/Systems
        a. Use tools/measuring instruments properly/safely
        b. Use drawings/manuals
        c. Understand consequences of adjustment
        d. Document adjustment/measurement
    7. Safely Assemble Electronic Modules, Cables, and Fittings
        a. Use tools properly/safely
        b. Use drawings/manuals
        c. Apply proper techniques for hydraulic or pneumatic assembly/disassembly
        d. Document assembly/disassembly
        e. Use proper safety procedures for hydraulic or pneumatic assembly
    8. Safely Adjust Servo Response, Process Controls (Including PID) and Motor Controls
        a. Use tools/measuring instruments properly/safely
        b. Use drawings/manuals
        c. Understand consequences of adjustment
        d. Document adjustment/measurement
    9. Safely Assemble Computers, PLCs, Communications Hardware and Robot DIO
        a. Use tools properly/safely
        b. Use drawings/manuals
        c. Apply proper techniques for hydraulic or pneumatic assembly/disassembly
        d. Document assembly/disassembly
        e. Use proper safety procedures for hydraulic or pneumatic assembly
    10. Troubleshoot Installation Starting at System, Then Subsystem, Module, or Component
        a. Identify system, subsystem, module, or component
        b. Apply theory of operation
        c. Measure system, subsystem, module, or component
        d. Analyze results to see if system, subsystem, module or component is performing to specifications
        e. Apply critical thinking to determine if measured system is malfunctioning or if identity, theory, or measurement is incorrect
        f. Validate the process and apply corrective action (i.e., repair)
        g. If the above process is incorrect, re-apply the process
    11. Repair the System or Subsystem by Replacing Modules or Components Using the above Assembly/Disassembly Processes

H. WORK AS A TEAM MEMBER IN A SIMULATED MANUFACTURING ENVIRONMENT IN THE BUILD UP OF A FLEXIBLE MANUFACTURING SYSTEM

    1. Participate in Team Projects and Contribute to the Team and Project
        a. Attend team meetings
        b. Contribute to the team
        c. Perform assigned project tasks
    2. Participate as a Member of a Company/Manufacturing Enterprise

    a. Report to work on time
    b. Exhibit ethical behavior
    c. Complete assigned reports/paperwork
    d. Suggest improvements
    e. Interrelate positively to fellow employees
    f. Follow company rules
    g. Exercise leadership

3. Apply Cooperation and Self-Management
    a. Manage time and resources
    b. Plan tasks
    c. Meet personal/team goals/schedules
    d. Cooperate with company management
4. Explain/Document Test Results with Team, Team Leaders, Engineers, Other Technicians, and Customers
    a. Use written English, write proper sentences
    b. Use written English, write following reports:
        1) Results of technical tests
        2) Instructions
        3) Engineering change orders
    c. Use word processor for reports
    d. Use spoken English to communicate
        1) Communicate thoughts, feelings, ideas
        2) Clearly communicate technical information to peers and customers

COURSE OBJECTIVES: SCANS COMPETENCIES

The Secretary's Commission on Achieving Necessary Skills (SCANS), U.S. Department of Labor, has identified in its "AMERICA 2000 REPORT" that all students should develop a new set of competencies and foundation skills if they are to enjoy a productive, full and satisfying life. These are in addition to the Technical Workplace Competencies required by industry. SCANS is made up of five competencies and a three-part foundation of skills and personal qualities that are needed for solid job performance.

The following activities will be performed by each student for successful completion of this course:

I. COMPETENCIES

- *A.* ***Resources:*** *Identifies, organizes, plans, and allocates resources*
    1. allocates time
        a. completes assigned work on time
        b. schedules goals/tasks
        c. reports to work on time
    2. allocates money
        a. meets projected budget expenses
        b. determines cost of component parts and suggests less expensive, equal or better components

        c. controls labor costs
    3. allocates material and facility resources
        a. plans material requirements to meet schedule
        b. acquires tools and distributes them
        c. organizes space requirements

B. Interpersonal: Works with others

1. participates as a member of a team
    a. participates in meetings
    b. plans/sets team goals
    c. performs team assigned tasks
2. teaches others
    a. helps team members solve problems
    b. contributes information to teams groups
3. satisfies internal/external customer requirements
4. exercises leadership
    a. communicates effectively to teams/groups
    b. motivates teams/study groups to succeed
    c. expresses ideas, feelings, and opinions clearly
    d. identifies whether the source of a position is an idea, feeling, or opinion
    e. provides supporting facts to support positions
5. expresses ideas and listens to others to solve team problems
6. works well with team and class members regardless of race class, ethnicity, or religion

C. Information: Acquires and uses information

1. acquires and evaluates Information
    a. obtains new or complementary information for various sources such as:
        1) text books
        2) lectures
        3) library
        4) periodicals
        5) internet
    b. evaluates information for accuracy, challenges information that contradicts logical evaluation
2. documents work/tasks, results of tests
3. gives oral/written presentations at team meetings
4. uses computers to program, document, analyze, and control systems

D. Systems: Understands complex inter-relationships

1. understands systems
    a. understands company structure
    b. understands team dynamics
    c. understands complex flexible manufacturing systems
2. monitors and corrects performance
    a. documents results of tests
    b. corrects systems from results of evaluation
3. finds alternate methods to solve production/troubleshooting/repair problems

- *E.* ***Technology:*** *Works with a variety of technologies*
  1. selects technology
     - a. applies the appropriate tools/measuring instruments to solve problems
     - b. understands the use of calculators/computers in solving math problems
  2. applies the proper tools/tests/measuring instruments to solve production/troubleshooting problems
  3. if system, subsystem, module, or component does not perform to specifications, finds problem

II. FOUNDATION SKILLS

- *A.* ***Basic Skills:*** *Reads, writes, performs arithmetic and mathematical operations, listens and speaks.*
  1. ***Reading:*** *Locates, understands, and interprets written information in prose and in documents such as manuals, graphs, and schedules*
     - a. reads assigned course material
     - b. interprets reading material to perform successfully in class
     - c. interprets graphical data from drawings/manuals
  2. ***Writing:*** *Communicates thoughts, ideas, information, and messages in writing; and creates documents such as letters, directions, manuals, reports, graphs, and flow charts*
     - a. write engineering change orders
     - b. writes reports of test results
  3. ***Arithmetic/Mathematics:*** *Perform basic computations and approaches practical problems by choosing appropriately from a variety of mathematical techniques*
     - a. performs mathematical computations using scientific notation
     - b. performs mathematical computations using engineering notation
     - c. applies the principles of plane geometry to solve technical problems
     - d. applies the principles of solid geometry to solve technical problems
     - e. applies the principles of trigonometry to solve technical problems
     - f. applies algebra to understand physical systems, and solve technical problems
  4. ***Listening:*** *Receives, attends to, interprets, and responds to verbal messages and other cues*
     - a. actively listens to the information being presented in class and feeds back concepts
     - b. listens to the ideas, feelings, and opinions of fellow classmates
  5. ***Speaking:*** *Organizes ideas and communicates orally*
     - a. presents ideas and information in class
     - b. contributes to classroom discussion.
- *B.* ***Thinking Skills:*** *Thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons.*
  1. ***Creative Thinking:*** *Generates new ideas*
     - a. combines mechanics, electricity, electronics, computer systems and programming to build a manufacturing process/system

2. ***Decision Making:*** *Specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternative*
    a. chooses most efficient method of constructing system/subsystems
    b. determines design of program for manufacturing system
3. ***Problem Solving:*** *Recognizes problems and devises and implements plan of action*
    a. determines nature of problem
    b. devises plan of action to solve problem and prevent future reoccurrences
4. ***Seeing Things In the Mind's Eye:*** *Organizes, and processes symbols, pictures, graphs, objects, and other information*
    a. visualizes the interrelationship between subsystems in complex flexible manufacturing system
5. ***Knowing How to Learn:*** *Use efficient learning techniques to acquire and apply new knowledge and skills*
    a. determines new knowledge necessary to accomplish tasks
    b. researches source of knowledge
    c. seeks help from other knowledgeable people
    d. practices to acquire new skills
6. ***Reasoning:*** *Discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem*
    a. applies the principles of physics, chemistry, mathematics, and computers to solving problems

C. ***Personal Qualities:*** *Displays responsibility, self-esteem, sociability, self-management, and integrity and honesty.*

1. ***Responsibility:*** *Exerts a high level of effort and perseveres towards goal attainment*
    a. performs at or above expected class level
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2. ***Self-Esteem:*** *Believes in own self-worth and maintains a positive view of self*
    a. contributes to classroom discussion with original ideas
    b. maintains a positive sense of humor that is not at the expense of another person's sense of self worth
3. ***Sociability:*** *Demonstrates understanding, friendliness, adaptability, empathy, and politeness in group settings*
    a. allows divergent views in class discussions
    b. responds positively to new ideas
    c. supports the worthwhile goals and objectives of the team and fellow classmates
4. ***Self-Management:*** *Assesses self accurately, sets personal goals, monitors progress, and exhibits self-control*
    a. accepts responsibility for completion of assigned work
    b. sets individual/group goals and accomplishes them
    c. maintains a record of accomplishments
5. ***Integrity/Honesty:*** *Chooses ethical courses of action*
    a. performs own work when required, does not plagiarize the work of others

b. protects school property

c. does not misappropriate the property of the school or other classmates

d. reports infractions of school rules to school authorities

Appropriate Reference Materials:

1. Industrial Computing, Pub. of Instrument Society of America (ISA)
2. Motion Control, Pub. of Instrument Society of America (ISA)
3. SME Journal, Pub. of Society of Manufacturing Engineers (SME)
4. Manufacturing Engineering, Pub. of Society of Manufacturing Engineers (SME)

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APPENDIX A - INDUSTRY COMPETENCY PROFILES

The following pages contain the individual Competency Profiles for each of the companies surveyed by the MAST development center for the occupational specialty area of . These Competency Profiles/skill standards were used to develop the curriculum for the pilot program.

The participation of the companies as partners in the MAST effort is greatly appreciated. Each company has approved the use of its logo in MAST materials. None of the participating companies shall be held responsible or liable for any of the findings of the project.

SKILLS AND KNOWLEDGE

Communication Skills
Use Measurement Tools
Use Inspection Devices
Mathematical Skills
Reading/Writing Skills
Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
Mechanical Aptitude
Ability to Comprehend Written/Verbal Instructions
Basic Knowledge of Fasteners
Ability to Work as Part of a Team
Converse in the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Knowledge of Company Quality Assurance Activities
Practice Quality-Consciousness in Performance of the Job
Knowledge of Computers
CAD/CAM Experience
Manual Machining Experience

SAN DIEGO CITY COLLEGE CENTER FOR APPLIED COMPETITIVE TECHNOLOGIES (CACT) MAST PROGRAM REPRESENTATIVES

DR. JOAN A. STEPSIS
Dean/Director-CACT

DOUG WELCH
Subject Matter Expert

FACILITATED BY:

MARY BENARD
Site Coordinator

LOUIS A. SPAIN, JR.
Consultant

CHARLES DAVIS
Participant

TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Eager to Learn
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Customer Relations
Personal Ethics

TOOLS AND EQUIPMENT FOR AET

Hand Tools

Hand tools appropriate to the construction, repair, and maintenance of electrical equipment such as electrical control systems and electrical motors

Hand tools appropriate to the construction, repair, and maintenance of electronic equipment such as computer controlled automated machinery

Hand tools appropriate to the construction, repair, and maintenance of hydraulic or pneumatic systems and components

Equipment

Power supplies
Electronics test units
Electrical test units
Hydraulic test units
Pneumatic test units
Electrical components
Wire and cable, connectors
Computers 386, 486
Digital electronic components
Robot Programming software
PLC Programming software
Robots, SCARA and Articulated
Pneumatic manipulators
Pneumatic fittings/components
Programmable Logic Controllers
Alignment/Calibration tools
Tool storage equipment
Vises
Electrical motors
Stepper motors
Electronic motor controls
Electronic components
Electronic enclosures
Electrical enclosures
Analog multimeters
Digital multimeters
Oscilloscopes
FMS Programming software
CNC machines
Robot, pneumatic (bang-bang)
Hydraulic/pneumatic components
Hydraulic fittings/components
Heat treatment equipment
Personal safety equipment
Workbenches
Weld test equipment
Coordinate Measurement Machine
Motion control servo systems test units
Wire termination devices, terminal lugs, etc.
Measuring instruments for mechanical parts - accuracy to .0001 inch
Hand held PLC programming terminals
Temperature, pressure, force, rotational velocity, and chemical measuring instruments
Welding equipment (SMAW, GMAW, FCAW)

CURRENT TRENDS/CONCERNS

Statistical Process Control
Laser Machining
Environmental concerns
Automated Material Handling Equipment
Computer Integrated Manufacturing
Advanced Computer Appplications
Composites
Robotics
Fiber Optic Controls

COMPETENCY PROFILE

Automated Equipment Technician/CIM

Prepared By
M.A.S.T.
Machine Tool Advanced Skills
Technology Program
and
Consortium Partners
(V.199J40008)

Davis *Technologies*

AUTOMATED EQUIPMENT TECHNICIAN/CIM .... operates, programs, maintains, and repairs automated machine tools and automated manufacturing processes.

	Duties	Tasks												
A	Apply science to solve industrial problems	A-1 Apply scientific notation and engineering notation to solve technical problems	A-2 Apply algebraic formulas to solve technical problems	A-3 Use variables in algebraic formulas to predict behavior of industrial systems	A-4 Manipulate variables in algebraic formulas to analyze industrial systems	A-5 Use physics, algebra, and trigonometry to analyze simple vectored forces	A-6 Use mechanical physics to analyze mechanical industrial systems	A-7 Measure, calculate, and convert quantities in English and Metric (SI,mks) systems						
B	Use drawings to analyze and repair systems	B-1 Use symbols, organization, and engineering values on mechanical drawings												
C	Use calibrated measuring instruments to test/calibrate components	C-1 Apply machine tool metrology and measurement instruments to align machine tools												
D	Explain test results to team leaders, engineers, customers, and other technicians	D-1 Use written English language; write complete proper sentences	D-2 Use written English language to effectively communicate results of technical tests and instructions	D-3 Use a word processor, obtain information from various sources and write effective reports	D-4 Use spoken English language to communicate feelings, thoughts, ideas, and technical information									
E	Resolve system failures with critical thinking, troubleshooting, theory and Metrology	E-1 Identify nature/purpose of a system, subsystem, module, or component in a complex manufacturing machine/process	E-2 Apply theory to predict behavior of a complex manufacturing machine or process	E-3 Evaluate complex manufacturing machine/process to determine if meeting theoretical expectations	E-4 Analyze results to determine if system, subsystem, module, or component is meeting manufacturers specifications	E-5 Apply critical thinking to determine if system is malfunctioning or if process must be remedied	E-6 Validate the process and apply corrective action	E-7 If corrective action does not result in repair of system, reapply the process						
F	Apply computer science to computer controlled industrial equipment	F-1 Use various programming concepts to program industrial equipment												
G	Correct malfunctions in PLC controlled industrial equipment	G-1 Use a data entry device to setup and configure a PLC/PIC to control digital and analog input/output points												
H	Resolve malfunctions found in computer systems controlling manufacturing processes	H-1 Operate different classes of personal computers	H-2 Maintain hardware/software of a personal computer	H-3 Configure and troubleshoot communications interfaces										
I	Assemble/disassemble mechanical, electrical, electronic, and computer systems	I-1 Safely assemble or disassemble mechanical systems such as gearing systems, shafts, couplings, pulleys, belts												
J	Use teamwork to accomplish job tasks and contribute to success of the company	J-1 Participate in team projects and contribute to success of the team and the project	J-2 Participate as a member of manufacturing enterprise and contribute to success of the company	J-3 Apply cooperation and self management techniques to work with members the of team and accomplish tasks										

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SKILLS AND KNOWLEDGE

Communication Skills
Use Measurement Tools
Use Inspection Devices
Mathematical Skills
Reading/Writing Skills
Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
Mechanical Aptitude
Ability to Comprehend Written/Verbal Instructions
Basic Knowledge of Fasteners
Ability to Work as Part of a Team
Converse in the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Knowledge of Company Quality Assurance Activities
Practice Quality-Consciousness in Performance of the Job
Ability to go into a Company and Continuously Train Others
ISO9000
Clear/Concise Writing and Communication Skills
Internal and External Proposal Writing
Clearly Communicate Technical Language
Use of Computers for Design, Product Development, and Word Processing

SAN DIEGO CITY COLLEGE
CENTER FOR APPLIED COMPETITIVE TECHNOLOGIES (CACT)
MAST PROGRAM REPRESENTATIVES

DR. JOAN A. STEPSIS
Dean/Director-CACT

DOUG WELCH
Subject Matter Expert

FACILITATED BY:

MARY BENARD
Site Coordinator

LOUIS A. SPAIN, JR.
Consultant

CACT

TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Customer Relations
Personal Ethics

TOOLS AND EQUIPMENT FOR AET

Hand Tools

Hand tools appropriate to the construction, repair, and maintenance of electrical equipment such as electrical control systems and electrical motors
Hand tools appropriate to the construction, repair, and maintenance of electronic equipment such as computer controlled automated machinery
Hand tools appropriate to the construction, repair, and maintenance of hydraulic or pneumatic systems and components

Equipment

Power supplies
Electronics test units
Electrical test units
Hydraulic test units
Pneumatic test units
Electrical components
Wire and cable, connectors
Computers 386, 486
Digital electronic components
Robot Programming software
PLC Programming software
Robots, SCARA and Articulated
Pneumatic manipulators
Pneumatic fittings/components
Programmable Logic Controllers
Alignment/Calibration tools
Tool storage equipment
Vises
Electrical motors
Stepper motors
Electronic motor controls
Electronic components
Electronic enclosures
Electrical enclosures
Analog multimeters
Digital multimeters
Oscilloscopes
FMS Programming software
CNC machines
Robot, pneumatic (bang-bang)
Hydraulic/pneumatic components
Hydraulic fittings/components
Heat treatment equipment
Personal safety equipment
Workbenches
Weld test equipment
Coordinate Measurement Machine
Motion control servo systems test units
Wire termination devices, terminal lugs, etc.
Measuring instruments for mechanical parts - accuracy to .0001 inch
Hand held PLC programming terminals
Temperature, pressure, force, rotational velocity, and chemical measuring instruments
Welding equipment (SMAW, GMAW, FCAW)

CURRENT TRENDS/CONCERNS

Statistical Process Control
Laser Machining
Environmental concerns
ISO9000
Composites
Robotics
Fiber Optic Controls
Automated Material Handling Equipment
Computer Integrated Manufacturing
Advanced Computer Appplications

COMPETENCY PROFILE

Automated Equipment Technician/CIM

Prepared By
M.A.S.T.
Machine Tool Advanced Skills
Technology Program
and
Consortium Partners
(V.199J40008)

CACT
CENTER FOR APPLIED COMPETITIVE TECHNOLOGIES

EATON
LEONARD

AUTOMATED EQUIPMENT TECHNICIAN/CIM .... operates, programs, maintains, and repairs automated machine tools and automated manufacturing processes.

	Duties	Tasks												
A	Apply science to solve industrial problems	A-1 Apply algebraic formulas to solve technical problems	A-2 Measure, calculate, and convert quantities in English and Metric (SI,mks) systems	A-3 Use math and mechanical physics to analyze problems found in hydraulic and pneumatic systems										
B	Use drawings to analyze and repair systems	B-1 Use symbols, organization, and engineering values on mechanical drawings	B-2 Use symbols, organization, and engineering values on electrical drawings	B-3 Use symbols, organization and engineering values on electronic drawings	B-4 Use symbols, organization and engineering values on fluid power drawings									
C	Use calibrated measuring instruments to test/calibrate components	C-1 Apply machine tool metrology and measurement instruments to align machine tools	C-2 Apply electrical measurement knowledge and instruments to test/calibrate electrical circuits	C-3 Apply electronic measurement knowledge and instruments to test/calibrate electronic circuits	C-4 Apply fluid power measurement and instruments to test/calibrate hydraulic and pneumatic systems	C-5 Apply digital electronic measurement knowledge and instruments to test/calibrate digital electronic circuits								
D	Explain test results to team leaders, engineers, customers, and other technicians	D-1 Use written English language; write complete proper sentences	D-2 Use written English language to effectively communicate results of technical tests and instructions	D-3 Use a word processor; obtain information from various sources and write effective reports	D-4 Use spoken English language to communicate feelings, thoughts, ideas, and technical information									
E	Resolve system failures with critical thinking, troubleshooting, theory and Metrology	E-1 Identify nature and purpose of a system, subsystem, module, or component in a complex manufacturing machine/process	E-2 Apply theory to predict behavior of a complex manufacturing machine or process	E-3 Measure complex manufacturing machine/process to determine if meeting theoretical expectations	E-4 Analyze results to determine if system, subsystem, module, or component is meeting manufacturers specifications	E-5 Apply critical thinking to determine if system is malfunctioning or if process must be reapplied	E-6 Validate the process and apply corrective action	E-7 If corrective action does not result in repair of system, reapply the process						
F	Use techniques to isolate malfunction of electronic systems	F-1 Calculate, predict and measure the response of quantities in DC circuits	F-2 Calculate, predict, and measure the response of quantities in AC circuits	F-3 Properly set-up, calibrate, and use meters and oscilloscopes	F-4 Use components such as resistors, inductors, and capacitors; construct circuits and test components	F-5 Use meters/oscilloscopes to measure phase shift or angle in series resistive-capacitive/resistive-inductive AC circuits	F-6 Apply electromagnetism theory to determine operational characteristics of relays, solenoids, transformers, and electrical motors for DC and AC circuits		F-7 Use meters and oscilloscopes to test magnetically coupled devices	F-8 Apply principles of DC electrical motors to identify types of DC motors	F-9 Apply principles of AC electrical motors to identify AC motors	F-10 Use rules of semiconductor devices and meters or oscilloscopes to test diodes	F-11 Use meters or oscilloscopes to test bipolar transistors and power MOSFETs	F-12 Use meters/oscilloscopes to test power control semi-conductors and their triggering devices
		F-13 Use meters/oscilloscopes to test power supply circuits, including rectifiers/filtering circuits for 1 and 3 phase DC power supplies	F-14 Use schematics and meters or oscilloscopes to identify, replace and/or troubleshoot and repair, series, shunt, and switching semiconductor, DC power supply, regulator circuits		F-15 Uses schematic diagrams and meters or oscilloscopes to identify advanced motor controls that contain newer, types of semiconductor devices, to troubleshoot and repair these motor controls		F-16 Apply semiconductor theory and amplifier concepts to troubleshoot and replace or repair the module containing the circuit		F-17 Use schematic diagrams and meters or oscilloscopes to test electrical devices	F-18 Use schematic diagrams and meters or oscilloscopes to test sensors				
G	Measure/isolate malfunctions of mechanical/fluid power systems	G-1 Know purpose and use of major systems that comprise a hydraulic/pneumatic system to troubleshoot components or systems	G-2 Apply purpose and use of valves in a hydraulic or pneumatic system to troubleshoot components or systems	G-3 Calculate, measure, and troubleshoot hydraulic and pneumatic accumulators	G-4 Use laws of simple machines and physics to identify and troubleshoot complex machines	G-5 Use laws of simple machines and physics to troubleshoot gearing systems								
H	Apply computer science to computer controlled industrial equipment	H-1 Solve digital logic circuits and ladder diagrams in electrical and programmable logic control circuits												
I	Correct malfunctions in PLC controlled industrial equipment	I-1 Use a data entry device to setup and configure a PLC/PIC to control digital and analog input/output points	I-2 Set up/configure PIC/PLC as part of control system of CNC machine/Robot to control digital and analog I/O points	I-3 Use equipment manuals, manufacturers specifications, and data entry/monitoring devices to connect and test digital and analog I/O points of a PLC or PIC		I-4 Use equipment manuals, manufacturers specifications, and data entry/monitoring devices to test and troubleshoot setup of a PLC or PIC system and solve control problems								

Eaton Leonard

	Duties	Tasks												
	Page 2													
J	Resolve malfunctions found in computer systems controlling manufacturing processes	J-1 Operate different classes of personal computers	J-2 Maintain hardware/software of a personal computer	J-3 Configure and troubleshoot communications interfaces	J-4 Test the hardware of a personal computer									
K	Assemble/disassemble mechanical, electrical, electronic, and computer systems	K-1 Safely assemble or disassemble mechanical systems such as gearing systems shafts, couplings, pulleys, belts	K-2 Adjust mechanical systems such as gearing systems, shafts, couplings, pulleys, and belts	K-3 Safely assemble or disassemble subsystems or components of fluid power systems	K-4 Adjust subsystems or components of fluid power systems	K-5 Safely assemble or disassemble electrical systems or components	K-6 Adjust electrical systems or components	K-7 Safely assemble or disassemble electronic systems or components	K-8 Safely adjust or components such tor control modules, proportional band controls	electronic systems as closed loop mo- servo systems, and integral derivative	K-9 Safely assemble or disassemble digital systems or components such as PLCs, CNCs or computers			
L	Use teamwork to accomplish job tasks and contribute to success of the company	L-1 Participate in team projects and contribute to success of the team and the project	L-2 Participate as a member of manufacturing enterprise and contribute to success of the company	L-3 Apply cooperation and self management techniques to work with members the of team and accomplish tasks										

EATON LEONARD
Panel Member

Marty Salazar
Machine Operator (Systems)

SKILLS AND KNOWLEDGE

Communication Skills
Use Measurement Tools
Use Inspection Devices
Mathematical Skills
Reading/Writing Skills
Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
Mechanical Aptitude
Ability to Comprehend Written/Verbal Instructions
Basic Knowledge of Fasteners
Ability to Work as Part of a Team
Converse in the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Knowledge of Company Quality Assurance Activities
Practice Quality-Consciousness in Performance of the Job
Deming
Leadership Skills
Self-Management
Flexible Leaderships
Basic Soldering (SMT)

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TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
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Neatness
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Motivation
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Customer Relations
Personal Ethics

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Pneumatic test units
Electrical components
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Digital electronic components
Coordinate Measurement Machine
Robot Programming software
PLC Programming software
Robots, SCARA and Articulated
Hydraulic/pneumatic components
Pneumatic fittings/components
Programmable Logic Controllers
Alignment/Calibration tools
Tool storage equipment
Vises
Electrical motors
Stepper motors
Electronic motor controls
Electronic components
Electronic enclosures
Electrical enclosures
Analog multimeters
Digital multimeters
Oscilloscopes
FMS Programming software
CNC machines
Robot, pneumatic (bang-bang)
Pneumatic manipulators
Hydraulic fittings/components
Heat treatment equipment
Personal safety equipment
Workbenches
Weld test equipment
Computers 386, 486; IBM; spreadsheets; word processors
Measuring instruments for mechanical parts--accuracy to .0001 inch
Temperature, pressure, force, rotational velocity, and chemical measuring instrumentsHand held PLC programming terminals
Wire termination devices, terminal lugs, etc.
Motion control servo systems test units
Welding equipment (SMAW, GMAW, FCAW)

CURRENT TRENDS/CONCERNS

Statistical Process Control
Laser Machining
Environmental concerns
Automated Material Handling Equipment
Computer Integrated Manufacturing
Advanced Computer Appplications
Composites
Robotics
Fiber Optic Controls

COMPETENCY PROFILE

Automated Equipment Technician/CIM

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Machine Tool Advanced Skills
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AUTOMATED EQUIPMENT TECHNICIAN/CIM .... operates, programs, maintains, and repairs automated machine tools and automated manufacturing processes.

	Duties	Tasks												
A	Apply science to solve industrial problems	A-1 Apply scientific notation and engineering notation to solve technical problems	A-2 Apply algebraic formulas to solve technical problems	A-3 Use variables in algebraic formulas to predict behavior of industrial systems	A-4 Manipulate variables in algebraic formulas to analyze industrial systems	A-5 Use physics, algebra, and trigonometry to analyze simple vectored forces	A-6 Use mechanical physics to analyze mechanical industrial systems	A-7 Measure, calculate, and convert quantities in English and Metric (SI,mks) systems	A-8 Use math and mechanical physics to analyze problems found in hydraulic, and pneumatic systems	A-9 Use math and thermodynamics to analyze problems found in industrial heat treating systems	A-10 Use math, the physics of electromagnetism and optics to analyze industrial systems	A-11 Use math, physics, and chemical measurements to determine physical quantities	A-12 Use math and chemical measurements to determine compounds, solutions, or mixtures	A-13 Use proper lab procedures to test chemicals used in industrial processes
	Perform Measurements	A-14 Use chemical formulas to predict and analyze reactions in industrial processes	A-15 Use proper laboratory methods to test the properties of elements and compounds	A-16 Apply the knowledge of electrochemical effects to analyze chemical industrial processes	A-17 Apply properties of water to analyze industrial water treatment processes									
B	Use drawings to analyze and repair systems	B-1 Use symbols, organization, and engineering values on mechanical drawings	B-2 Use symbols, organization, and engineering values on electrical drawings	B-3 Use symbols, organization and engineering values on electronic drawings	B-4 Use symbols, organization and engineering values on fluid power drawings									
C	Use calibrated measuring instruments to test/calibrate components	C-1 Apply machine tool metrology and measurement instruments to align machine tools	C-2 Apply electrical measurement knowledge and instruments to test/calibrate electrical circuits	C-3 Apply electronic measurement knowledge and instruments to test/calibrate electronic circuits	C-4 Apply fluid power measurement and instruments to test/calibrate hydraulic and pneumatic systems	C-5 Apply digital electronic measurement knowledge and instruments to test/calibrate digital electronic circuits								
D	Explain test results to team leaders, engineers, customers, and other technicians	D-1 Use written English language, write complete proper sentences	D-2 Use written English language to effectively communicate results of technical tests and instructions	D-3 Use a word processor, obtain information from various sources and write effective reports	D-4 Use spoken English language to communicate feelings, thoughts, ideas, and technical information									
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F	Use techniques to isolate malfunction of electronic systems	F-1 Calculate, predict and measure the response of quantities in DC circuits	F-2 Calculate, predict, and measure the response of quantities in AC circuits	F-3 Calculate, predict and measure impedance and phase angle in AC circuits	F-4 Calculate, predict, and measure quantities in polyphase AC circuits	F-5 Properly set-up, calibrate, and use meters and oscilloscopes	F-6 Use components such as resistors, inductors, and capacitors; construct circuits and test components	F-7 Use meters/oscilloscopes to measure phase shift or angle in series resistive-capacitive/resistive-inductive AC circuits	F-8 Apply electromagnetism theory to determine operational characteristics of relays, solenoids, transformers, and electrical motors for DC and AC circuits		F-9 Use meters and oscilloscopes to test magnetically coupled devices	F-10 Apply principles of DC electrical motors to identify types of DC motors	F-11 Apply principles of AC electrical motors to identify AC motors	F-12 Use rules of semiconductor devices and meters or oscilloscopes to test diodes
		F-13 Use meters or oscilloscopes to test bipolar transistors and power MOSFETs	F-14 Use meters/oscilloscopes to test power control semi-conductors and their triggering devices	F-15 Use meters/oscilloscopes to test power supply circuits, including rectifiers/filtering circuits for 1 and 3 phase DC power supplies	F-16 Use schematics and meters or oscilloscopes to identify, replace and/or troubleshoot and repair, series, shunt, and switching semiconductor, DC power supply, regulator circuits		F-17 Use schematics and meters or oscilloscopes to differentiate between various types of DC motor control circuits and replace and/or troubleshoot and repair these motor controls		F-18 Uses schematic diagrams and meters or oscilloscopes to identify advanced motor controls that contain newer, types of semiconductor devices, to troubleshoot and repair these motor controls		F-19 Apply semiconductor theory and amplifier concepts to troubleshoot and replace or repair the module containing the circuit		F-20 Use schematic diagrams and meters or oscilloscopes to test electrical devices	F-21 Use schematic diagrams and meters or oscilloscopes to test sensors
G	Measure/isolate malfunctions of mechanical/fluid power systems	G-1 Know purpose and use of major systems that comprise a hydraulic/pneumatic system to troubleshoot components or systems	G-2 Apply purpose and use of valves in a hydraulic or pneumatic system to troubleshoot components or systems	G-3 Use formulas and mathematics to calculate quantities in hydraulic and pneumatic systems	G-4 Use fluid power measuring instruments to test the operating condition of the fluid power system	G-5 Test the condition and behavior of fluids in a fluid power system	G-6 Use the knowledge of flow; measure flow in a fluid power system	G-7 Calculate, measure, and troubleshoot hydraulic and pneumatic accumulators	G-8 Apply hydraulic, pneumatic, and high vacuum systems knowledge to test, troubleshoot, and repair special components/devices	G-9 Identify, assemble, measure and apply knowledge of operating characteristics of selected, specialized fluid power circuits	G-10 Identify, assemble, measure, and apply knowledge of operating characteristics of electrically operated, specialized fluid power circuits	G-11 Understand and use proper instruments and troubleshooting methods for fluid power circuits	G-12 Use laws of simple machines and physics to identify and troubleshoot complex machines	G-13 Use laws of simple machines and physics to troubleshoot gearing systems
H	Apply computer science to computer controlled industrial equipment	H-1 Convert mathematical quantities in digital numbering systems	H-2 Perform mathematical operations in digital numbering systems	H-3 Read digital symbology and relate it to control of digitally operated equipment	H-4 Express a complex logic problem in Boolean, and convert it into symbolic logic	H-5 Solve digital logic circuits and ladder diagrams in electrical and programmable logic control circuits	H-6 Express a complex logic problem in Boolean and convert it into ladder logic	H-7 Use various programming devices and Boolean algebra to program computer controlled industrial equipment	H-8 Use various programming concepts to program industrial equipment					

Duties		Tasks												
	Page 2													
I	Correct malfunctions in PLC controlled industrial equipment	I-1 Use a data entry device to setup and configure a PLC/PIC to control digital and analog input/output points	I-2 Set up/configure PIC/PLC as part of control system of CNC machine/Robot to control digital and analog I/O points	I-3 Use equipment manuals, manufacturers specifications, and data entry/monitoring devices to connect and test digital and analog I/O points of a PLC or PIC		I-4 Use equipment manuals, manufacturers specifications, and data entry/monitoring devices to test and troubleshoot setup of a PLC or PIC system and solve control problems								
J	Resolve malfunctions found in computer systems controlling manufacturing processes	J-1 Operate different classes of personal computers	J-2 Maintain hardware/software of a personal computer	J-3 Configure and troubleshoot communications interfaces	J-4 Test the hardware of a personal computer									
K	Assemble/disassemble mechanical, electrical, electronic, and computer systems	K-1 Safely assemble or disassemble mechanical systems such as gearing systems, shafts, couplings, pulleys, belts	K-2 Adjust mechanical systems such as gearing systems, shafts, couplings, pulleys, and belts	K-3 Safely assemble or disassemble subsystems or components of fluid power systems	K-4 Adjust subsystems or components of fluid power systems	K-5 Safely assemble or disassemble electrical systems or components	K-6 Adjust electrical systems or components	K-7 Safely assemble or disassemble electronic systems or components	K-8 Safely adjust electronic systems or components such as closed loop motor control modules, servo systems, and proportional band integral derivative controls		K-9 Safely assemble or disassemble digital systems or components such as PLCs, CNCs or computers			
L	Use teamwork to accomplish job tasks and contribute to success of the company	L-1 Participate in team projects and contribute to success of the team and the project	L-2 Participate as a member of manufacturing enterprise and contribute to success of the company	L-3 Apply cooperation and self management techniques to work with members of team and accomplish tasks										

NASSCO
Panel Members

Charles Zigelman, CFPIM Manager Fabrication	James L. Clark Maintenance General Foreman
Marcus Lopez Machine Operator	Silvestre De La Torres Cutting Machine Operator

SKILLS AND KNOWLEDGE

Communication Skills
Use Measurement Tools
Use Inspection Devices
Mathematical Skills
Reading/Writing Skills
Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
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Converse in the Technical Language of the Trade
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Practice Quality-Consciousness in Performance of the Job

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TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Ability to Think
Willingness to Continue Education
Motivation
Responsible
Physical Ability
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Trustworthy
Customer Relations
Personal Ethics

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Programmable Logic Controllers
Alignment/Calibration tools
Tool storage equipment
Vises
Electrical motors
Stepper motors/Micro steppers
Electronic motor controls
Electronic components
Electronic enclosures
Electrical enclosures
Computers 386, 486, PCI Pentium 586
Digital multimeters
Oscilloscopes
FMS Programming software
CNC machines
Robot, pneumatic (bang-bang)
Hydraulic/pneumatic components
Hydraulic fittings/components
Heat treatment equipment
Personal safety equipment
Workbenches
Weld test equipment
Coordinate Measurement Machine
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Measuring instruments for mechanical parts - accuracy to .0001 inch
Hand held PLC programming terminals
Temperature, pressure, force, rotational velocity, and chemical measuring instruments
Welding equipment (SMAW, GMAW, FCAW)

CURRENT TRENDS/CONCERNS

Statistical Process Control
Laser Machining
Environmental concerns
Automated Material Handling Equipment
Computer Integrated Manufacturing
Advanced Computer Applications
Composites
Robotics
Fiber Optic Controls

COMPETENCY PROFILE

Automated Equipment Technician/CIM

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ROHR

AUTOMATED EQUIPMENT TECHNICIAN/CIM .... operates, programs, maintains, and repairs automated machine tools and automated manufacturing processes.

Duties	Tasks →												
A Apply science to solve industrial problems	A-1 Apply scientific notation and engineering notation to solve technical problems	A-2 Apply algebraic formulas to solve technical problems	A-3 Manipulate variables in algebraic formulas to analyze industrial systems	A-4 Use physics, algebra, and trigonometry to analyze simple vectored forces	A-5 Measure, calculate, and convert quantities in English and Metric (SI,mks) systems	A-6 Use math and mechanical physics to analyze problems found in hydraulic and pneumatic systems	A-7 Use math and thermodynamics to analyze problems found in industrial heat treating systems	A-8 Use math, the physics of electromagnetism and optics to analyze industrial systems	A-9 Use math, physics, and chemical measurements to determine physical quantities	A-10 Use math and chemical measurements to determine compounds, solutions, or mixtures	A-11 Use proper lab procedures to test chemicals used in industrial processes	A-12 Use chemical formulas to predict and analyze reactions in industrial processes	A-13 Use proper laboratory methods to test the properties of elements and compounds
Perform Measurements	A-14 Apply the knowledge of electrochemical effects to analyze chemical industrial processes	A-15 Apply properties of water to analyze industrial water treatment processes											
B Use drawings to analyze and repair systems	B-1 Use symbols, organization, and engineering values on mechanical drawings	B-2 Use symbols, organization, and engineering values on electrical drawings	B-3 Use symbols, organization and engineering values on electronic drawings	B-4 Use symbols, organization and engineering values on fluid power drawings									
C Use calibrated measuring instruments to test/calibrate components	C-1 Apply machine tool metrology and measurement instruments to align machine tools	C-2 Apply electrical measurement knowledge and instruments to test/calibrate electrical circuits	C-3 Apply electronic measurement knowledge and instruments to test/calibrate electronic circuits	C-4 Apply fluid power measurement and instruments to test/calibrate hydraulic and pneumatic systems	C-5 Apply digital electronic measurement knowledge and instruments to test/calibrate digital electronic circuits								
D Explain test results to team leaders, engineers, customers, and other technicians	D-1 Use written English language; write complete proper sentences	D-2 Use written English language to effectively communicate results of technical tests and instructions	D-3 Use a word processor, obtain information from various sources and write effective reports	D-4 Use spoken English language to communicate feelings, thoughts, ideas, and technical information									
E Resolve system failures with critical thinking, troubleshooting, theory and Metrology	E-1 Identify [illegible] purpose of a system, subsystem, module, or component in a complex manufacturing machine/process	E-2 Apply theory to predict behavior of a complex manufacturing machine or process	E-3 Measure complex manufacturing machine/process to determine if meeting theoretical expectations	E-4 Analyze results to determine if system, subsystem, module, or component is meeting manufacturers specifications	E-5 Apply critical thinking to determine if system is malfunctioning or if process must be reapplied	E-6 Validate the process and apply corrective action	E-7 If corrective action does not result in repair of system, reapply the process						
F Use techniques to isolate malfunction of electronic systems	F-1 Calculate, predict and measure the response of quantities in DC circuits	F-2 Calculate, predict, and measure the response of quantities in AC circuits	F-3 Calculate, predict and measure impedance and phase angle in AC circuits	F-4 Calculate, predict, and measure quantities in polyphase AC circuits	F-5 Properly set-up, calibrate, and use meters and oscilloscopes	F-6 Use components such as resistors, inductors, and capacitors; construct circuits and test components	F-7 Use meters/oscilloscopes to measure phase shift or angle in series resistive-capacitive/resistive-inductive AC circuits	F-8 Apply electromagnetism theory to determine operational characteristics of relays, solenoids, transformers, and electrical motors for DC and AC circuits		F-9 Use meters and oscilloscopes to test magnetically coupled devices	F-10 Apply principles of DC electrical motors to identify types of DC motors	F-11 Apply principles of AC electrical motors to identify AC motors	F-12 Use rules of semiconductor devices and meters or oscilloscopes to test diodes
	F-13 Use meters or oscilloscopes to test bipolar transistors and power MOSFETs	F-14 Use meters/oscilloscopes to test power control semi-conductors and their triggering devices	F-15 Use meters/oscilloscopes to test power supply circuits, including rectifiers/filtering circuits for 1 and 3 phase DC power supplies	F-16 Use schematics and meters or oscilloscopes to identify, replace and/or troubleshoot and repair, series, shunt, and switching semiconductor, DC power supply, regulator circuits		F-17 Use schematics and meters or oscilloscopes to differentiate between various types of DC motor control circuits and replace and/or troubleshoot and repair these motor controls		F-18 Uses schematic diagrams and meters or oscilloscopes to identify advanced motor controls that contain newer, types of semiconductor devices, to troubleshoot and repair these motor controls		F-19 Apply semiconductor theory and amplifier concepts to troubleshoot and replace or repair the module containing the circuit		F-20 Use schematic diagrams and meters or oscilloscopes to test electrical devices	F-21 Use schematic diagrams and meters or oscilloscopes to test sensors
G Measure/Isolate malfunctions of mechanical/fluid power systems	G-1 Know purpose and use of major systems that comprise a hydraulic/pneumatic system to troubleshoot components or systems	G-2 Apply purpose and use of valves in a hydraulic or pneumatic system to troubleshoot components or systems	G-3 Use formulas and mathematics to calculate quantities in hydraulic and pneumatic systems	G-4 Use fluid power measuring instruments to test the operating condition of the fluid power system	G-5 Test the condition and behavior of fluids in a fluid power system	G-6 Use the knowledge of flow; measure flow in a fluid power system	G-7 Calculate, measure, and troubleshoot hydraulic and pneumatic accumulators	G-8 Apply hydraulic, pneumatic, and high vacuum systems knowledge to test, troubleshoot, and repair special components/devices	G-9 Identify, assemble, measure and apply knowledge of operating characteristics of selected, specialized fluid power circuits	G-10 Identify, assemble, measure, and apply knowledge of operating characteristics of electrically operated, specialized fluid power circuits	G-11 Understand and use proper instruments and troubleshooting methods for fluid power circuits		
H Apply computer science to computer controlled industrial equipment	H-1 Convert mathematical quantities in digital numbering systems	H-2 Perform mathematical operations in digital numbering systems	H-3 Read digital symbology and relate it to control of digitally operated equipment	H-4 Express a complex logic problem in Boolean, and convert it into symbolic logic	H-5 Solve digital logic circuits and ladder diagrams in electrical and programmable logic control circuits	H-6 Use various programming devices and Boolean algebra to program computer controlled industrial equipment	H-7 Use various programming concepts to program industrial equipment						

Rohr

Duties		Tasks												
	Page 2													
I	Correct malfunctions in PLC controlled industrial equipment	I-1 Use a data entry device to setup and configure a PLC/PIC to control digital and analog input/output points	I-2 Set up/configure PIC/PLC as part of control system of CNC machine/Robot to control digital and analog I/O points	I-3 Use equipment manuals, manufacturers specifications, and data entry/monitoring devices to connect and test digital and analog I/O points of a PLC or PIC		I-4 Use equipment manuals, manufacturers specifications, and data entry/monitoring devices to test and troubleshoot setup of a PLC or PIC system and solve control problems								
J	Resolve malfunctions found in computer systems controlling manufacturing processes	J-1 Operate different classes of personal computers	J-2 Maintain hardware/software of a personal computer	J-3 Configure and troubleshoot communications interfaces	J-4 Test the hardware of a personal computer									
K	Assemble/disassemble mechanical, electrical, electronic, and computer systems	K-1 Safely assemble or disassemble mechanical systems such as gearing systems, shafts, couplings, pulleys, belts	K-2 Adjust mechanical systems such as gearing systems, shafts, couplings, pulleys, and belts	K-3 Safely assemble or disassemble subsystems or components of fluid power systems	K-4 Adjust subsystems or components of fluid power systems	K-5 Safely assemble or disassemble electrical systems or components	K-6 Adjust electrical systems or components	K-7 Safely assemble or disassemble electronic systems or components	K-8 Safely adjust electronic systems or components such as closed loop motor control modules, servo systems, and proportional band integral derivative controls		K-9 Safely assemble or disassemble digital systems or components such as PLCs, CNCs or computers			
L	Use teamwork to accomplish job tasks and contribute to success of the company	L-1 Participate in team projects and contribute to success of the team and the project	L-2 Participate as a member of manufacturing enterprise and contribute to success of the company	L-3 Apply cooperation and self management techniques to work with members of team and accomplish tasks										

ROHR
Panel Members

Greg Harris Manager	Mike Harrington Maintenance Chief	Harold Thurber Technician

SKILLS AND KNOWLEDGE

Communication Skills
Use Measurement Tools
Use Inspection Devices
Mathematical Skills
Reading/Writing Skills
Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
Mechanical Aptitude
Ability to Comprehend Written/Verbal Instructions
Basic Knowledge of Fasteners
Ability to Work as Part of a Team
Converse in the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Knowledge of Company Quality Assurance Activities
Practice Quality-Consciousness in Performance of the Job

SAN DIEGO CITY COLLEGE
CENTER FOR APPLIED COMPETITIVE TECHNOLOGIES (CACT)
MAST PROGRAM REPRESENTATIVES

DR. JOAN A. STEPSIS
Dean/Director-CACT

DOUG WELCH
Subject Matter Expert

FACILITATED BY:

MARY BENARD
Site Coordinator

LOUIS A. SPAIN, JR.
Consultant

SOUTHWEST FABRICATORS
Panel Members

JIM FLOYD, Shop Foreman
LEON VAN ORSDALE, Maintenance

TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Customer Relations
Personal Ethics

TOOLS AND EQUIPMENT FOR AET

Hand Tools

Hand tools appropriate to the construction, repair, and maintenance of electrical equipment such as electrical control systems and electrical motors
Hand tools appropriate to the construction, repair, and maintenance of electronic equipment such as computer controlled automated machinery
Hand tools appropriate to the construction, repair, and maintenance of hydraulic or pneumatic systems and components

Equipment

Power supplies
Electronics test units
Electrical test units
Hydraulic test units
Pneumatic test units
Electrical components
Wire and cable, connectors
Computers 386, 486
Digital electronic components
FMS Programming software
Hydraulic/pneumatic components
Pneumatic fittings/components
Programmable Logic Controllers
Personal safety equipment
Tool storage equipment
Workbenches
Electrical motors
Stepper motors
Electronic motor controls
Electronic components
Electronic enclosures
Electrical enclosures
Analog multimeters
Digital multimeters
Oscilloscopes
PLC Programming software
Hydraulic fittings/components
CNC machines
Alignment/Calibration tools
Weld test equipment
Vises
Motion control servo systems test units
Wire termination devices, terminal lugs, etc.
Temperature, pressure, force, rotational velocity, and chemical measuring instruments
Welding equipment (SMAW, GMAW, FCAW)

CURRENT TRENDS/CONCERNS

Statistical Process Control
Laser Machining
Environmental concerns
Automated Material Handling Equipment
Computer Integrated Manufacturing
Advanced Computer Appplications
Composites
Robotics
Fiber Optic Controls

COMPETENCY PROFILE

Automated Equipment Technician/CIM

Prepared By
M.A.S.T.
Machine Tool Advanced Skills Technology Program
and
Consortium Partners
(V.199J40008)

AUTOMATED EQUIPMENT TECHNICIAN/CIM .... operates, programs, maintains, and repairs automated machine tools and automated manufacturing processes.

	Duties	Tasks												
A	Apply science to solve industrial problems	A-1 Apply scientific notation and engineering notation to solve technical problems	A-2 Apply algebraic formulas to solve technical problems	A-3 Use variables in algebraic formulas to predict behavior of industrial systems	A-4 Manipulate variables in algebraic formulas to analyze industrial systems	A-5 Use physics, algebra, and trigonometry to analyze simple vectored forces	A-6 Use mechanical physics to analyze mechanical industrial systems	A-7 Measure, calculate, and convert quantities in English and Metric (SI,mks) systems	A-8 Use math and mechanical physics to analyze problems found in hydraulic, and pneumatic systems	A-9 Use math and thermodynamics to analyze problems found in industrial heat treating systems	A-10 Use math, the physics of electromagnetism and optics to analyze industrial systems	A-11 Use math, physics, and chemical measurements to determine physical quantities	A-12 Use math and chemical measurements to determine compounds, solutions, or mixtures	A-13 Use proper lab procedures to test chemicals used in industrial processes
B	Use drawings to analyze and repair systems	B-1 Use symbols, organization, and engineering values on mechanical drawings	B-2 Use symbols, organization, and engineering values on electrical drawings	B-3 Use symbols, organization and engineering values on electronic drawings	B-4 Use symbols, organization and engineering values on fluid power drawings							A-14 Use chemical formulas to predict and analyze reactions in industrial processes	A-15 Use proper laboratory methods to test the properties of elements and compounds	A-16 Apply properties of water to analyze industrial water treatment processes
C	Use calibrated measuring instruments to test/calibrate components	C-1 Apply machine tool metrology and measurement instruments to align machine tools	C-2 Apply electrical measurement knowledge and instruments to test/calibrate electrical circuits	C-3 Apply electronic measurement knowledge and instruments to test/calibrate electronic circuits	C-4 Apply fluid power measurement and instruments to test/calibrate hydraulic and pneumatic systems	C-5 Apply digital electronic measurement knowledge and instruments to test/calibrate digital electronic circuits								
D	Explain test results to team leaders, engineers, customers, and other technicians	D-1 Use written English language; write complete proper sentences	D-2 Use written English language to effectively communicate results of technical tests and instructions	D-3 Use spoken English language to communicate feelings, thoughts, ideas, and technical information										
E	Resolve system failures with critical thinking, troubleshooting, theory and Metrology	E-1 Identify use or purpose of a system, subsystem, module, or component in a complex manufacturing machine/process	E-2 Apply theory to predict behavior of a complex manufacturing machine or process	E-3 Measure complex manufacturing machine/process to determine if meeting theoretical expectations	E-4 Analyze results to determine if system, subsystem, module, or component is meeting manufacturers specifications	E-5 Apply critical thinking to determine if system is malfunctioning or if process must be remodeled	E-6 Validate the process and apply corrective action	E-7 If corrective action does not result in repair of system, reapply the process						
F	Use techniques to isolate malfunction of electronic systems	F-1 Calculate, predict and measure the response of quantities in DC circuits	F-2 Calculate, predict, and measure the response of quantities in AC circuits	F-3 Calculate, predict and measure impedance and phase angle in AC circuits	F-5 Properly set-up, calibrate, and use meters and oscilloscopes	F-6 Use components such as resistors, inductors, and capacitors; construct circuits and test components	F-7 Apply electromagnetism theory to determine operational characteristics of relays, solenoids, transformers, and electrical motors for DC and AC circuits		F-9 Use meters and oscilloscopes to test magnetically coupled devices	F-10 Apply principles of DC electrical motors to identify types of DC motors	F-20 Use schematic diagrams and meters or oscilloscopes to test electrical devices	F-21 Use schematic diagrams and meters or oscilloscopes to test sensors		
G	Measure/Isolate malfunctions of mechanical/fluid power systems	G-1 Know purpose and use of major systems that comprise a hydraulic/pneumatic system to troubleshoot components or systems	G-2 Apply purpose and use of valves in a hydraulic or pneumatic system to troubleshoot components or systems	G-3 Use formulas and mathematics to calculate quantities in hydraulic and pneumatic systems	G-4 Use fluid power measuring instruments to test the operating condition of the fluid power system	G-5 Test the condition and behavior of fluids in a fluid power system	G-6 Use the knowledge of flow; measure flow in a fluid power system	G-7 Calculate, measure, and troubleshoot hydraulic and pneumatic accumulators	G-8 Apply hydraulic, pneumatic, and high vacuum systems knowledge to test, troubleshoot, and repair special components/devices	G-9 Identify, assemble, measure and apply knowledge of operating characteristics of selected, specialized fluid power circuits	G-10 Identify, assemble, measure, and apply knowledge of operating characteristics of electrically operated, specialized fluid power circuits	G-11 Understand and use proper instruments and troubleshooting methods for fluid power circuits	G-12 Use laws of simple machines and physics to identify and troubleshoot complex machines	G-13 Use laws of simple machines and physics to troubleshoot gearing systems
H	Resolve malfunctions found in computer systems controlling manufacturing processes	H-1 Operate different classes of personal computers	H-2 Maintain hardware/software of a personal computer	H-3 Configure and troubleshoot communications interfaces	H-4 Test the hardware of a personal computer									
I	Use teamwork to accomplish job tasks and contribute to success of the company	I-1 Participate in team projects and contribute to success of the team and the project	I-2 Participate as a member of manufacturing enterprise and contribute to success of the company	I-3 Apply cooperation and self management techniques to work with members of team and accomplish tasks										
J	Assemble/disassemble mechanical, electrical, electronic, and computer systems	J-1 Safely assemble or disassemble mechanical systems such as gearing systems, shafts, couplings, pulleys, belts	J-2 Adjust mechanical systems such as gearing systems, shafts, couplings, pulleys, and belts	J-3 Safely assemble or disassemble subsystems or components of fluid power systems	J-4 Adjust subsystems or components of fluid power systems	J-5 Safely assemble or disassemble electrical systems or components	J-6 Adjust electrical systems or components	J-7 Safely assemble or disassemble electronic systems or components	J-8 Safely adjust electronic systems or components such as closed loop motor control modules, servo systems, and proportional band integral derivative controls		J-9 Safely assemble or disassemble digital systems or components such as PLCs, CNCs or computers			

Southwest Fabricators

SKILLS AND KNOWLEDGE

Communication Skills
Use Measurement Tools
Use Inspection Devices
Mathematical Skills
Reading/Writing Skills
Knowledge of Safety Regulations
Practice Safety in the Workplace
Organizational Skills
Knowledge of Company Policies/Procedures
Mechanical Aptitude
Ability to Comprehend Written/Verbal Instructions
Basic Knowledge of Fasteners
Ability to Work as Part of a Team
Converse in the Technical Language of the Trade
Knowledge of Occupational Opportunities
Knowledge of Employee/Employer Responsibilities
Knowledge of Company Quality Assurance Activities
Practice Quality-Consciousness in Performance of the Job

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Subject Matter Expert

FACILITATED BY

LOUIS A. SPAIN, JR.
Consultant

CACT
San Diego City College

TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Environmental Concerns
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Customer Relations
Personal Ethics

TOOLS AND EQUIPMENT FOR AET

Hand Tools

Hand tools appropriate to the construction, repair, and maintenance of electrical equipment such as electrical control systems and electrical motors
Hand tools appropriate to the construction, repair, and maintenance of electronic equipment such as computer controlled automated machinery
Hand tools appropriate to the construction, repair, and maintenance of hydraulic or pneumatic systems and components
Hand tools appropriate to the construction, repair, and maintenance of basic mechanical systems and components

Equipment

Power supplies
Electronics test units
Electrical test units
Hydraulic test units
Pneumatic test units
Electrical components
Wire and cable, connectors
Computers 386, 486
Digital electronic components
Robot Programming software
PLC Programming software
Robots, SCARA and Articulated
Pneumatic manipulators
Pneumatic fittings/components
Programmable Logic Controllers
Alignment/Calibration tools
Tool storage equipment
Vises
Electrical motors
Stepper motors
Electronic motor controls
Electronic components
Electronic enclosures
Electrical enclosures
Analog multimeters
Digital multimeters
Oscilloscopes
FMS Programming software
CNC machines
Robot, pneumatic (bang-bang)
Hydraulic/pneumatic components
Hydraulic fittings/components
Heat treatment equipment
Personal safety equipment
Workbenches
Weld test equipment
Coordinate Measurement Machine
Motion control servo systems test units
Wire termination devices, terminal lugs, etc.
Measuring instruments for mechanical parts - accuracy to .0001 inch
Hand held PLC programming terminals
Temperature, pressure, force, rotational velocity, and chemical measuring instruments
Welding equipment (SMAW, GMAW, FCAW)

CURRENT TRENDS/CONCERNS

Statistical Process Control
Laser Machining
Environmental concerns
Automated Material Handling Equipment
Computer Integrated Manufacturing
Advanced Computer Appplications
Composites
Robotics
Fiber Optic Controls

COMPETENCY PROFILE

Automated Equipment Technician/CIM

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CACT
CENTER FOR APPLIED COMPETITIVE TECHNOLOGIES

TELEDYNE
RYAN AERONAUTICAL

AUTOMATED EQUIPMENT TECHNICIAN/CIM .... operates, programs, maintains, and repairs automated machine tools and automated manufacturing processes.

Duties	Tasks												
A Apply science to solve industrial problems	A-1 Apply scientific notation and engineering notation to solve technical problems	A-2 Apply algebraic formulas to solve technical problems	A-3 Use variables in algebraic formulas to predict behavior of industrial systems	A-4 Manipulate variables in algebraic formulas to analyze industrial systems	A-5 Use physics, algebra, and trigonometry to analyze simple vectored forces	A-6 Use mechanical physics to analyze mechanical industrial systems	A-7 Measure, calculate, and convert quantities in English and Metric (SI,cgs) systems	A-8 Use math and mechanical physics to analyze problems found in hydraulic and pneumatic systems	A-9 Use math and thermodynamics to analyze problems found in industrial heat treating systems	A-10 Use math, the physics of electromagnetism and optics to analyze industrial systems	A-11 Use math, physics, and chemical measurements to determine physical quantities	A-12 Use math and chemical measurements to determine compounds, solutions, or mixtures	A-13 Use proper lab procedures to test chemicals used in industrial processes
Perform Measurements	A-14 Use chemical formulas to predict and analyze reactions in industrial processes	A-15 Use proper laboratory methods to test the properties of elements and compounds	A-16 Apply the knowledge of electrochemical effects to analyze chemical industrial processes	A-17 Apply properties of water to analyze industrial water treatment processes									
B Use drawings to analyze and repair systems	B-1 Use symbols, organization, and engineering values on mechanical drawings	B-2 Use symbols, organization, and engineering values on electrical drawings	B-3 Use symbols, organization and engineering values on electronic drawings	B-4 Use symbols, organization and engineering values on fluid power drawings									
C Use calibrated measuring instruments to test/calibrate components	C-1 Apply machine tool metrology and measurement instruments to align machine tools	C-2 Apply electrical measurement knowledge and instruments to test/calibrate electrical circuits	C-3 Apply electronic measurement knowledge and instruments to test/calibrate electronic circuits	C-4 Apply fluid power measurement and instruments to test/calibrate hydraulic and pneumatic systems	C-5 Apply digital electronic measurement knowledge and instruments to test/calibrate digital electronic circuits								
D Explain test results to team leaders, engineers, customers, and other technicians	D-1 Use written English language, write complete proper sentences	D-2 Use written English language to effectively communicate results of technical tests and instructions	D-3 Use a word processor, obtain information from various sources and write effective reports	D-4 Use spoken English language to communicate feelings, thoughts, ideas, and technical information									
E Resolve system failures with critical thinking, troubleshooting, theory and Metrology	E-1 Identify intent/purpose of a system, subsystem, module, or component in a complex manufacturing machine/process	E-2 Apply theory to predict behavior of a complex manufacturing machine or process	E-3 Measure complex manufacturing machine/process to determine if meeting theoretical expectations	E-4 Analyze results to determine if system, subsystem, module, or component is meeting manufacturer's specifications	E-5 Apply critical thinking to determine if system is malfunctioning or if process must be modified	E-6 Validate the process and apply corrective action	E-7 If corrective action does not result in repair of system, reapply the process						
F Use techniques to isolate malfunction of electronic systems	F-1 Calculate, predict and measure the response of quantities in DC circuits	F-2 Calculate, predict, and measure the response of quantities in AC circuits	F-3 Calculate, predict and measure impedance and phase angle in AC circuits	F-4 Calculate, predict, and measure quantities in polyphase AC circuits	F-5 Properly set-up, calibrate, and use meters and oscilloscopes	F-6 Use components such as resistors, inductors, and capacitors; construct circuits and test components	F-7 Use meters/oscilloscopes to measure phase shift or angle in series resistive-capacitive/resistive-inductive AC circuits	F-8 Apply electromagnetism theory to determine operational characteristics of relays, solenoids, transformers, and electrical motors for DC and AC circuits		F-9 Use meters and oscilloscopes to test magnetically coupled devices	F-10 Apply principles of DC electrical motors to identify types of DC motors	F-11 Apply principles of AC electrical motors to identify AC motors	F-12 Use rules of semiconductor devices and meters or oscilloscopes to test diodes
	F-13 Use meters or oscilloscopes to test bipolar transistors and power MOSFETs	F-14 Use meters/oscilloscopes to test power control semi-conductors and their triggering devices	F-15 Use meters/oscilloscopes to test power supply circuits, including rectifier/filtering circuits for 1 and 3 phase DC power supplies	F-16 Use schematics and meters or oscilloscopes to identify, replace and/or troubleshoot and repair, motor, diode, and switching semiconductor, DC power supply, regulator circuits		F-17 Use schematics and meters or oscilloscopes to differentiate between various types of DC motor control circuits and replace and/or troubleshoot and repair these motor controls		F-18 Uses schematic diagrams and meters or oscilloscopes to identify advanced motor controls that contain sensor, types of semiconductor devices, to troubleshoot and repair these motor controls		F-19 Apply semiconductor theory and amplifier concepts to troubleshoot and replace or repair the module containing the circuit		F-20 Use schematic diagrams and meters or oscilloscopes to test electrical devices	F-21 Use schematic diagrams and meters or oscilloscopes to test sensors
G Measure/isolate malfunctions of mechanical/fluid power systems	G-1 Know purpose and use of major systems that comprise a hydraulic/pneumatic system to troubleshoot components of systems	G-2 Apply purpose and use of valves in a hydraulic or pneumatic system to troubleshoot components or systems	G-3 Use formulas and mathematics to calculate quantities in hydraulic and pneumatic systems	G-4 Use fluid power measuring instruments to test the operating condition of the fluid power system	G-5 Test the condition and behavior of fluids in a fluid power system	G-6 Use the knowledge of flow; measure flow in a fluid power system	G-7 Calculate, measure, and troubleshoot hydraulic and pneumatic accumulators	G-8 Apply hydraulic, pneumatic, and high vacuum systems knowledge to test, troubleshoot, and repair special components/devices	G-9 Identify, assemble, measure and apply knowledge of operating characteristics of selected, specialized fluid power circuits	G-10 Identify, assemble, measure, and apply knowledge of operating characteristics of electrically operated, specialized fluid power circuits	G-11 Understand and use proper instruments and troubleshooting methods for fluid power circuits	G-12 Use laws of simple machines and physics to identify and troubleshoot complex machines	G-13 Use laws of simple machines and physics to troubleshoot gearing systems
H Apply computer science to computer controlled industrial equipment	H-1 Convert mathematical quantities in digital numbering systems	H-2 Perform mathematical operations in digital numbering systems	H-3 Read digital symbology and relate it to control of digitally operated equipment	H-4 Express a complex logic problem in Boolean, and convert it into symbolic logic	H-5 Solve digital logic circuits and ladder diagrams in electrical and programmable logic control circuits	H-6 Express a complex logic problem in Boolean and convert it into ladder logic	H-7 Use various programming devices and Boolean algebra to program computer controlled industrial equipment	H-8 Use various programming concepts to program industrial equipment					

Teledyne Ryan

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Duties	Tasks												
Page 2													
I Correct malfunctions in PLC controlled industrial equipment	I-1 Use a data entry device to setup and configure a PLC/PIC to control digital and analog input/output points	I-2 Set up/configure PIC/PLC as part of control system of CNC machine/Robot to control digital and analog I/O points	I-3 Use equipment manuals, manufacturers specifications, and data entry/monitoring devices to connect and test digital and analog I/O points of a PLC or PIC		I-4 Use equipment manuals, manufacturers specifications, and data entry/monitoring devices to test and troubleshoot setup of a PLC or PIC system and solve control problems								
J Resolve malfunctions found in computer systems controlling manufacturing processes	J-1 Operate different classes of personal computers	J-2 Maintain hardware/software of a personal computer	J-3 Configure and troubleshoot communications interfaces	J-4 Test the hardware of a personal computer									
K Assemble/disassemble mechanical, electrical, electronic, and computer systems	K-1 Safely assemble or disassemble mechanical systems such as gearing systems, shafts, couplings, pulleys, belts	K-2 Adjust mechanical systems such as gearing systems, shafts, couplings, pulleys, and belts	K-3 Safely assemble or disassemble subsystems or components of fluid power systems	K-4 Adjust subsystems or components of fluid power systems	K-5 Safely assemble or disassemble electrical systems or components	K-6 Adjust electrical systems or components	K-7 Safely assemble or disassemble electronic systems or components	K-8 Safely adjust electronic systems or components such as closed loop motor control modules, servo systems, and proportional band integral derivative controls		K-9 Safely assemble or disassemble digital systems or components such as PLCs, CNCs or computers			
L Use teamwork to accomplish job tasks and contribute to success of the company	L-1 Participate in team projects and contribute to success of the team and the project	L-2 Participate as a member of manufacturing enterprise and contribute to success of the company	L-3 Apply cooperation and self management techniques to work with members of team and accomplish tasks										

TELEDYNE RYAN AERONAUTICALS
Panel Members

Chuck Kolva
Maintenance Manager

SKILLS AND KNOWLEDGE

Communication Skills
Technical Reading/Writing Skills
Ability to Comprehend Written/Verbal Instructions
Leadership Skills
Organizational Skills
Knowledge of Company Policies/Procedures
Knowledge of Employee/Employer Responsibilities
Ability to Work as Part of a Team
Knowledge of Company Quality Assurance Activities
Knowledge of Safety Regulations/Responsibilities
Project/Task Management Skills
Logical/Systematic Problem Solving Skills
Computer Skills
Numerical/Mathematical Skills
Use Measurement Tools
Use Inspection Devices
Drafting Skills
Knowledge of Industrial Materials
Knowledge of Manufacturing Processes
Mechanical Aptitude

ITAWAMBA COMMUNITY COLLEGE MAST PROGRAM REPRESENTATIVES

Dr. Charles Chrestman
Dean/Director

Don Benjamin
Associate Dean/Site Administrator

Barry Emison
Site Coordinator

AIRCAP/MTD REPRESENTATIVES

Raymond Ball
Maintenance Manager

Donald Clark
Maintenance Technician

Steve Taylor
Maintenance Supervisor

Neil E. Wiseman
Quality Manager

Robert Wright
Maintenance Supervisor

TRAITS AND ATTITUDES

Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Personal Ethics
Innovative

TOOLS AND EQUIPMENT

Machinist Tools
Mechanic's Tools
Electrician's Tools
Measuring Tools
Power Tools
Hydraulic / Arbor Press
Alignment/Calibration Tools
Computer
Personal Safety Equipment
Tool Storage Equipment
Workbenches
Vises

CURRENT TRENDS/CONCERNS

Adaptive Controls
Composites
In-Process Gauging
Rapid Tool Changing
Expanded Communication with Shop Floor
Multi-Axis Equipment
Computer-Integrated Manufacturing
Artificial Intelligence
Conversational Programming

COMPETENCY PROFILE

Computer-Integrated-Manufacturing Technician

Prepared By
M.A.S.T.
Machine Tool Advanced Skills
Technology Program
and
Consortium Partners
(V.199J40008)

AIRCAP/MTD

COMPUTER-INTEGRATED-MANUFACTURING TECHNICIAN .... install, maintain, troubleshoot, repair and integrate manufacturing systems which use computers to control and sequence equipment and processes

Duties		← Tasks →												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Maintain safe equipment and machinery	A-3 Maintain a clean and safe work environment	A-4 Ensure safe operation of machines	A-5 Use safe machining practices	A-6 Use safe lifting practices	A-7 Use safe operating procedures for hand and machine tools	A-8 Consult and apply MSDS for hazards of various materials	A-9 Practice proper tag-out/ lock-out procedures	A-10 Practice electrical safety procedures			
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Interconvert fractions/ decimals	B-3 Interconvert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Perform basic trigonometric functions	B-6 Use basic geometric principles	B-7 Calculate and apply formulas	B-8 Use and apply basic concepts of technical physics	B-9 Use and apply cartesian coordinate system				
C	Demonstrate Quality Control and Management	C-1 Utilize appropriate inspection techniques	C-2 Perform appropriate use and calibration of inspection equipment	C-3 Know qualitative parameters of machinery and equipment	C-4 Know operation of coordinate measuring machine	C-5 Maintain equipment to produce quality parts	C-6 Know and use SFC techniques and concepts	C-7 Write inspection procedures	C-8 Document inspection results	C-9 Know and use ISO 9000 concepts and procedures	C-10 Know and use TQM techniques			
D	Demonstrate Knowledge of Manufacturing Materials	D-1 Identify materials with desired properties	D-2 Know machinability/ workability of various materials	D-3 Apply concepts of and calculate statics and stresses	D-4 Know/Find hardness characteristics/ chemistry of various material	D-5 Demonstrate knowledge of heat treating procedures and properties	D-6 Determine, interpret, and evaluate availability of materials	D-7 Know stress relieving procedures	D-8 Apply knowledge of lubrication techniques and fluids					
E	Demonstrate Knowledge of Manufacturing Processes	E-1 Know operation of vertical and horizontal mills and tooling	E-2 Know operation of engine and turret lathes and tooling	E-3 Know operation of drill presses and tooling	E-4 Know operation of surface and cylindrical grinders	E-5 Know operation of heat treating equipment and processes	E-6 Know operation of welding equipment	E-7 Know operation of ga cutting equipment	E-8 Know operation of punch / brake presses and tooling	E-9 Know operation of plate shears	E-10 Know operation of jig-boring machines and tooling	E-11 Know operation of tool and cutter grinders	E-12 Know operation of band saws	E-13 Estimate time required/ cost to produce a part
		E-14 Know proper flow of parts through shop	E-15 Schedule preventive maintenance for tooling and/ or machine	E-16 Calculate tonnages required for press operations	E-17 Calculate bend allowances / use yield tables for sheet metal operations	E-18 Apply conservation of material concepts	E-19 Calculate speeds and feeds based on materials and tooling	E-20 Utilize concepts and principles of fixturing	E-21 Make calculations for sine bar/plate	E-22 Know basic concepts of industrial painting/plating	E-23 Make calculations for rotary table and dividing head	E-24 Know operation of wire EDM	E-25 Know operation of laser machining systems	
F	Perform CNC Programming/ CAM Tasks	F-1 Prepare and plan for CNC machining operations	F-2 Select, use, and acquire tooling systems for CNC machines	F-3 Manually program CNC machines	F-4 Set and use tooling offsets at CNC machine	F-5 Use Computer-Aided-Manufacturing (CAM) system	F-6 Configure CAM system parameters	F-7 Interconvert CAD and CAM files using DXF or IGES formats	F-8 Install and maintain file transfer systems					
G	Perform Measurement/ Inspection	G-1 Know operation of O.D., I.D., and depth micrometers	G-2 Know operation of vernier, dial, & digital calipers	G-3 Read and use scale and tape measure	G-4 Know operation of dial-bore indicators	G-5 Know operation of dial indicators	G-6 Use precision square, center head, and protractor	G-7 Use digital read-out	G-8 Use finish/ profile gauges	G-9 Know operation of Rockwell hardness tester	G-10 Use oscilloscope	G-11 Know / use multimeter	G-12 Know / use meg-ohm meter (megger)	
H	Demonstrate Communication Skills	H-1 Read, interpret, and apply memorandums, letters, and written instructions	H-2 Read, interpret, and apply technical reports, procedures and manuals	H-3 Communicate technical information verbally	H-4 Read, interpret, and apply graphs, charts, and other visual aids	H-5 Write technical reports, procedures, and guidelines	H-6 Write memorandums, letters, or instructions							
I	Perform Drafting/CAD Tasks	I-1 Demonstrate traditional mechanical drafting skills	I-2 Use Computer-Aided Drafting (CAD) system	I-3 Interconvert CAD and DXF or IGES formats	I-4 Use and apply GD&T methodology	I-5 Generate and/or apply industry or company standards								

MTDCIM PM5
MAST95/111095

Duties		Tasks												
J	Use Computers	J-1 Use computer operating systems	J-2 Use file management systems	J-3 Perform backup on a personal computer	J-4 Install/use software packages	J-5 Use computer network system	J-6 Use file transfer systems	J-7 Understand and apply computer terminology	J-8 Have working knowledge of hardware components	J-9 Understand RS-232 protocol				
K	Demonstrate knowledge of machine systems	K-1 Install, repair, and maintain electronic systems and components	K-2 Install, repair, and maintain electrical systems and components	K-3 Install, repair, and maintain hydraulic/pneumatic systems and components	K-4 Install, repair, and maintain mechanical systems and components	K-5 Install, repair, and maintain robotic systems and components	K-6 Install, repair, and maintain conveyor systems and components	K-7 Install, repair, and maintain CNC controls and components						
L	Interpret/Use Blueprints and Related Documents	L-1 Interpret, review, and apply blueprint notes, dimensions, and tolerances	L-2 Interpret and understand basic layout/types of drawings	L-3 Understand and analyze bill of materials	L-4 Ascertain job requirements from drawings	L-5 Interpret and apply geometric dimensioning and tolerancing	L-6 Interpret and apply electrical schematic diagrams	L-7 Interpret and apply hydraulic or pneumatic diagrams	L-8 Interpret and apply plant layout drawings	L-9 Interpret and apply digital / ladder logic diagrams				
M	Manage Projects/Tasks	M-1 Compile and collate information	M-2 Conduct multiple project management	M-3 Set and maintain timelines	M-4 Prioritize tasks/duties/projects	M-5 Preplan project activities	M-6 Demonstrate time/resource management	M-7 Perform research	M-8 Comprehend entire scope of project	M-9 Assess and evaluate / Revise or modify project layout				
N	Demonstrate Electrical / Electronic Skills	N-1 Install, program, and troubleshoot PLC	N-2 Install, Program, and troubleshoot robotics equipment	N-3 Install, troubleshoot, and use motor controls	N-4 Install, troubleshoot, and use solid state devices	N-5 Troubleshoot electrical /electronic system and components	N-6 Troubleshoot hydraulic / pneumatic systems and components	N-7 Troubleshoot mechanical systems and components						

SKILLS AND KNOWLEDGE
Communication Skills
Technical Reading/Writing Skills
Ability to Comprehend Written/Verbal Instructions
Leadership Skills
Organizational Skills
Knowledge of Company Policies/Procedures
Knowledge of Employee/Employer Responsibilities
Ability to Work as Part of a Team
Knowledge of Company Quality Assurance Activities
Knowledge of Safety Regulations/Responsibilities
Project/Task Management Skills
Logical/Systematic Problem Solving Skills
Computer Skills
Numerical/Mathematical Skills
Use Measurement Tools
Use Inspection Devices
Drafting Skills
Knowledge of Industrial Materials
Knowledge of Manufacturing Processes
Mechanical Aptitude

ITAWAMBA COMMUNITY COLLEGE MAST PROGRAM REPRESENTATIVES

Dr. Charles Chrestman
Dean/Director

Don Benjamin
Associate Dean/Site Administrator

Barry Emison
Site Coordinator

DELTA REPRESENTATIVES

Ronald Gibson
Electronics Technician

Jerry Riley
CNC Specialist

Edith Sherrill
CNC Maintenance Technician

Thad Snowden
CNC Maintenance Technician

Donnie Turner
CNC Maintenance Technician

TRAITS AND ATTITUDES
Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Personal Ethics
Innovative

TOOLS AND EQUIPMENT
Machinist Tools
Mechanic's Tools
Electrician's Tools
Measuring Tools
Power Tools
Hydraulic / Arbor Press
Alignment/Calibration Tools
Computer
Personal Safety Equipment
Tool Storage Equipment
Workbenches
Vises

CURRENT TRENDS/CONCERNS
Rapid Tool Changing
Expanded Communication with Shop Floor
Multi-Axis Equipment
Computer-Integrated Manufacturing

COMPETENCY PROFILE

Computer-Integrated-Manufacturing Technician

Prepared By
M.A.S.T.
Machine Tool Advanced Skills
Technology Program
and
Consortium Partners
(V.199J40008)

DELTA
A Pentair Company

COMPUTER-INTEGRATED-MANUFACTURING TECHNICIAN .... install, maintain, troubleshoot, repair and integrate manufacturing systems which use computers to control and sequence equipment and processes

Duties		Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Maintain safe equipment and machinery	A-3 Maintain a clean and safe work environment	A-4 Ensure safe operation of machines	A-5 Use safe machining practices	A-6 Use safe lifting practices	A-7 Use safe operating procedures for hand and machine tools	A-8 Consult and apply MSDS for hazards of various materials	A-9 Practice proper tag-out/ lock-out procedures	A-10 Practice electrical safety procedures			
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Inter-convert fractions/ decimals	B-3 Inter-convert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Perform basic trigonometric functions	B-6 Use basic geometric principles	B-7 Calculate and apply formulas	B-8 Use and apply basic concepts of technical physics					
C	Demonstrate Quality Control and Management	C-1 Utilize appropriate inspection techniques	C-2 Perform appropriate use and calibration of inspection equipment	C-3 Know qualitative parameters of machinery and equipment	C-4 Know operation of coordinate measuring machine	C-5 Maintain equipment to produce quality parts	C-6 Know and use SPC techniques and concepts	C-7 Write inspection procedures	C-8 Document inspection results	C-9 Know and use ISO 9000 concepts and procedures	C-10 Know and use TQM techniques			
D	Demonstrate Knowledge of Manufacturing Materials	D-1 Identify materials with desired properties	D-2 Know machinability/ workability of various materials	D-3 Apply concepts of and calculate statics and stresses	D-4 Know/Find hardness characteristics/ chemistry of various material	D-5 Demonstrate knowledge of heat treating procedures and properties	D-6 Determine, interpret, and evaluate availability of materials							
E	Demonstrate Knowledge of Manufacturing Processes	E-1 Know operation of vertical and horizontal mills and tooling	E-2 Know operation of engine and turret lathes and tooling	E-3 Know operation of drill presses and tooling	E-4 Know operation of surface and cylindrical grinders	E-5 Know operation of laser machining systems	E-6 Know operation of welding equipment	E-7 Know operation of gas cutting equipment	E-8 Know operation of punch / brake presses and tooling	E-9 Know operation of plate shears	E-10 Know operation of wire EDM	E-11 Know operation of tool and cutter grinders	E-12 Know operation of band saws	E-13 Calculate speeds and feeds based on materials and tooling
		E-14 Schedule preventive maintenance for tooling and/ or machine	E-15 Have knowledge of CNC programming language											
F	Perform CNC Programming/ CAM Tasks	F-1 Manually edit programs at CNC machines	F-2 Set and use tooling offsets at CNC machine	F-3 Install and maintain file transfer systems										
G	Perform Measurement/ Inspection	G-1 Know operation of O.D., I.D., and depth micrometers	G-2 Know operation of vernier, dial, & digital calipers	G-3 Read and use scale and tape measure	G-4 Know operation of dial-bore indicators	G-5 Know operation of dial indicators	G-6 Know/ use meg-ohm meter (megger)	G-7 Use digital read-out	G-8 Use finish/ profile gauges	G-9 Know and use tachometer	G-10 Use oscilloscope	G-11 Know/ use multimeter		
H	Demonstrate Communication Skills	H-1 Read, interpret, and apply memorandums, letters, and written instructions	H-2 Read, interpret, and apply technical reports, procedures and manuals	H-3 Communicate technical information verbally	H-4 Read, interpret, and apply graphs, charts, and other visual aids	H-5 Write technical reports, procedures, and guidelines	H-6 Write memorandums, letters, or instructions							
I	Manage Projects/Tasks	I-1 Compile and collate information	I-2 Conduct multiple project management	I-3 Set and maintain timelines	I-4 Prioritize tasks/duties/ projects	I-5 Preplan project activities	I-6 Demonstrate time/resource management	I-7 Perform research	I-8 Comprehend entire scope of project	I-9 Assess and evaluate / Revise or modify project layout				

DELTACIM FMS
MASTER/111095

	Duties	Tasks												
J	Use Computers	J-1 Use computer operating systems	J-2 Use file management systems	J-3 Perform backup on a personal computer	J-4 Install/use software packages	J-5 Use computer network system	J-6 Use file transfer systems	J-7 Understand and apply computer terminology	J-8 Have working knowledge of hardware components	J-9 Understand RS-232 protocol				
K	Demonstrate Electrical / Electronic Skills	K-1 Install, program, and troubleshoot PLC	K-2 Install, Program, and troubleshoot robotics equipment	K-3 Install, troubleshoot, and use motor controls	K-4 Install, troubleshoot, and use solid state devices	K-5 Troubleshoot electrical /electronic system and components	K-6 Troubleshoot hydraulic / pneumatic systems and components	K-7 Troubleshoot mechanical systems and components						
L	Interpret/Use Blueprints and Related Documents	L-1 Interpret, review, and apply blueprint notes, dimensions, and tolerances	L-2 Interpret and understand basic layout/ types of drawings	L-3 Interpret and apply digital / ladder logic diagrams	L-4 Ascertain jcb requirements from drawings	L-5 Interpret and apply geometric dimensioning and tolerancing	L-6 Interpret and apply electrical schematic diagrams	L-7 Interpret and apply hydraulic or pneumatic diagrams	L-8 Interpret and apply plant layout drawings					
M	Demonstrate knowledge of machine systems	M-1 Install, repair, and maintain electronic systems and components	M-2 Install, repair, and maintain electrical systems and components	M-2 Install, repair, and maintain hydraulic/ pneumatic systems and components	M-4 Install, repair, and maintain mechanical systems and components	M-5 Install, repair, and maintain robotic systems and components	M-6 Install, repair, and maintain conveyor systems and components	M-7 Install, repair, and maintain CNC controls and components						

DELTACIM PM3
MAFT01/11095

SKILLS AND KNOWLEDGE
Communication Skills
Technical Reading/Writing Skills
Ability to Comprehend Written/Verbal Instructions
Leadership Skills
Organizational Skills
Knowledge of Company Policies/Procedures
Knowledge of Employee/Employer Responsibilities
Ability to Work as Part of a Team
Knowledge of Company Quality Assurance Activities
Knowledge of Safety Regulations/Responsibilities
Project/Task Management Skills
Logical/Systematic Problem Solving Skills
Computer Skills
Numerical/Mathematical Skills
Use Measurement Tools
Use Inspection Devices
Drafting Skills
Knowledge of Industrial Materials
Knowledge of Manufacturing Processes
Mechanical Aptitude

ITAWAMBA COMMUNITY COLLEGE MAST PROGRAM REPRESENTATIVES

Dr. Charles Chrestman
Dean/Director

Don Benjamin
Associate Dean/Site Administrator

Barry Emison
Site Coordinator

HUNTER DOUGLAS REPRESENTATIVES

Thomas Grimes
Electrical Engineering Technician

Phillip Hopper
Quality Control Manager

Dan Hurt
Technical Services Manager

Tom Lensie
Maintenance Engineering Manager

Henk Meewis
Engineering Manager

Jim Wall
Technical Services Assistant Manager

TRAITS AND ATTITUDES
Strong Work Ethic
Interpersonal Skills
Punctuality
Dependability
Honesty
Neatness
Safety Conscientious
Motivation
Responsible
Physical Ability
Professional
Trustworthy
Personal Ethics
Innovative

TOOLS AND EQUIPMENT
Machinist Tools
Mechanic's Tools
Electrician's Tools
Measuring Tools
Power Tools
Hydraulic / Arbor Press
Alignment/Calibration Tools
Computer
Personal Safety Equipment
Tool Storage Equipment
Workbenches
Vises

CURRENT TRENDS/CONCERNS
Adaptive Controls
Composites
In-Process Gauging
Rapid Tool Changing
Expanded Communication with Shop Floor
Multi-Axis Equipment
Computer-Integrated Manufacturing
Artificial Intelligence

COMPETENCY PROFILE

Computer-Integrated-Manufacturing Technician

Prepared By
M.A.S.T.
Machine Tool Advanced Skills
Technology Program
and
Consortium Partners
(V.199J40008)

COMPUTER-INTEGRATED-MANUFACTURING TECHNICIAN .... install, maintain, troubleshoot, repair and integrate manufacturing systems which use computers to control and sequence equipment and processes

	Duties	Tasks												
A	Practice Safety	A-1 Follow safety manuals and all safety regulations/ requirements	A-2 Maintain safe equipment and machinery	A-3 Maintain a clean and safe work environment	A-4 Ensure safe operation of machines	A-5 Use safe machining practices	A-6 Use safe lifting practices	A-7 Use safe operating procedures for hand and machine tools	A-8 Consult and apply MSDS for hazards of various materials	A-9 Practice proper tag-out/ lock-out procedures	A-10 Practice electrical safety procedures			
B	Apply Mathematical Concepts	B-1 Perform basic arithmetic functions	B-2 Interconvert fractions/ decimals	B-3 Interconvert Metric/ English measurements	B-4 Perform basic algebraic operations	B-5 Perform basic trigonometric functions	B-6 Use basic geometric principles	B-7 Calculate and apply formulas	B-8 Use and apply basic concepts of technical physics	B-9 Use and apply cartesian coordinate system				
C	Demonstrate Quality Control and Management	C-1 Utilize appropriate inspection techniques	C-2 Perform appropriate use and calibration of inspection equipment	C-3 Know qualitative parameters of machinery and equipment	C-4 Know operation of coordinate measuring machine	C-5 Maintain equipment to produce quality parts	C-6 Know and use SPC techniques and concepts	C-7 Write inspection procedures	C-8 Document inspection results	C-9 Know and use ISO 9000 concepts and procedures	C-10 Know and use TQM techniques			
D	Demonstrate Knowledge of Manufacturing Materials	D-1 Identify materials with desired properties	D-2 Know machinability/ workability of various materials	D-3 Apply concepts of and calculate statics and stresses	D-4 Know/Find hardness characteristics/ chemistry of various material	D-5 Demonstrate knowledge of heat treating procedures and properties	D-6 Determine, interpret, and evaluate availability of materials	D-7 Know stress relieving procedures						
E	Demonstrate Knowledge of Manufacturing Processes	E-1 Know operation of vertical and horizontal mills and tooling	E-2 Know operation of engine and turret lathes and tooling	E-3 Know operation of drill presses and tooling	E-4 Know operation of surface and cylindrical grinders	E-5 Know operation of heat treating equipment and processes	E-6 Know operation of welding equipment	E-7 Know operation of gas cutting equipment	E-8 Know operation of punch / brake presses and tooling	E-9 Know operation of plate shears	E-10 Know operation of jig-boring machines and tooling	E-11 Know operation of tool and cutter grinders	E-12 Know operation of band saws	E-13 Estimate time required/ cost to produce a part
		E-14 Know proper flow of parts through shop	E-15 Schedule preventive maintenance for tooling and/ or machine	E-16 Calculate tonnages required for press operations	E-17 Calculate bend allowances / use yield tables for sheet metal operations	E-18 Apply conservation of material concepts	E-19 Calculate speeds and feeds based on materials and tooling	E-20 Utilize concepts and principles of fixturing	E-21 Make calculations for sine bar/plate	E-22 Know basic concepts of industrial painting/plating	E-23 Make calculations for rotary table and dividing head	E-24 Know operation of wire EDM		
F	Perform CNC Programming/ CAM Tasks	F-1 Prepare and plan for CNC machining operations	F-2 Select, use, and acquire tooling systems for CNC machines	F-3 Manually program CNC machines	F-4 Set and use tooling offsets at CNC machine	F-5 Use Computer-Aided-Manufacturing (CAM) system	F-6 Transfer files from CAM system to machine	F-7 Interconvert CAD and CAM files using DXF or IGES formats	F-8 Install and maintain file transfer systems	F-9 Configure CAM system parameters				
G	Perform Measurement/ Inspection	G-1 Know operation of O.D., I.D., and depth micrometers	G-2 Know operation of vernier, dial, & digital calipers	G-3 Read and use scale and tape measure	G-4 Know operation of dial-bore indicators	G-5 Know operation of dial indicators	G-6 Use precision square, center head, and protractor	G-7 Use digital read-out	G-8 Use finish/ profile gauges	G-9 Know operation of Rockwell hardness tester	G-10 Use oscilloscope	G-11 Know/ use multimeter	G-12 Know/ use meg-ohm meter (megger)	
H	Demonstrate Communication Skills	H-1 Read, interpret, and apply memorandums, letters, and written instructions	H-2 Read, interpret, and apply technical reports, procedures and manuals	H-3 Communicate technical information verbally	H-4 Read, interpret, and apply graphs, charts, and other visual aids	H-5 Write technical reports, procedures, and guidelines	H-6 Write memorandums, letters, or instructions							
I	Perform Drafting/CAD Tasks	I-1 Demonstrate traditional mechanical drafting skills	I-2 Use Computer-Aided Drafting (CAD) system	I-3 Interconvert CAD and DXF or IGES formats	I-4 Use and apply GD&T methodology	I-5 Generate and/or apply industry or company standards								

Duties		Tasks												
J	Use Computers	J-1 Use computer operating systems	J-2 Use file management systems	J-3 Perform backup on a personal computer	J-4 Install/use software packages	J-5 Use computer network system	J-6 Use file transfer systems	J-7 Understand and apply computer terminology	J-8 Have working knowledge of hardware components	J-9 Understand RS-232 protocol				
K	Participate in Product Design Activities	K-1 Design parts for manufacturability	K-2 Design parts for functionality	K-3 Design parts for marketability	K-4 Plan and design for "mating of parts"	K-5 Be cost conscious with design of parts	K-6 Incorporate safety into product design	K-7 Determine, interpret, and evaluate customer specifications	K-8 Design, document, and validate testing methods	K-9 Coordinate production of prototype				
L	Interpret/Use Blueprints and Related Documents	L-1 Interpret, review, and apply blueprint notes, dimensions, and tolerances	L-2 Interpret and understand basic layout/ types of drawings	L-3 Understand and analyze bill of materials	L-4 Ascertain job requirements from drawings	L-5 Interpret and apply geometric dimensioning and tolerancing	L-6 Interpret and apply electrical schematic diagrams	L-7 Interpret and apply hydraulic or pneumatic diagrams	L-8 Interpret and apply plant layout drawings	L-9 Interpret and apply digital / ladder logic diagrams				
M	Manage Projects/Tasks	M-1 Compile and collate information	M-2 Conduct multiple project management	M-3 Set and maintain timelines	M-4 Prioritize tasks/duties/ projects	M-5 Preplan project activities	M-6 Demonstrate time/resource management	M-7 Perform research	M-8 Comprehend entire scope of project	M-9 Assess and evaluate / Revise or modify project layout				
N	Demonstrate Electrical / Electronic Skills	N-1 Install, program, and troubleshoot PLC	N-2 Install, Program, and troubleshoot robotics equipment	N-3 Install, troubleshoot, and use motor controls	N-4 Install, troubleshoot, and use solid state devices	N-5 Troubleshoot electrical /electronic system and components	N-6 Troubleshoot hydraulic / pneumatic systems and components	N-7 Troubleshoot mechanical systems and components						
O	Demonstrate knowledge of machine systems	O-1 Install, repair, and maintain electronic systems and components	O-2 Install, repair, and maintain electrical systems and components	O-2 Install, repair, and maintain hydraulic/ pneumatic systems and components	O-4 Install, repair, and maintain mechanical systems and components	O-5 Install, repair, and maintain robotic systems and components	O-6 Install, repair, and maintain conveyor systems and components	O-7 Install, repair, and maintain CNC controls and components						

SKILLS AND KNOWLEDGE

- Communication Skills
- Use Measurement Tools
- Use Inspection Devices
- Mathematical Skills
- Reading/Writing Skills
- Knowledge of Safety Regulations
- Practice Safety in the Workplace
- Organizational Skills
- Knowledge of Company Policies/Procedures
- Mechanical Aptitude
- Ability to Comprehend Written/Verbal Instructions
- Basic Knowledge of Fasteners
- Ability to Work as Part of a Team
- Converse in the Technical Language of the Trade
- Knowledge of Occupational Opportunities
- Knowledge of Employee/Employer Responsibilities
- Knowledge of Company Quality Assurance Activities
- Practice Quality-Consciousness in Performance of the Job
- Basic Machining Course Prerequisites or CNC Machinist Course Ware

TEXAS STATE TECHNICAL COLLEGE WACO MAST PROGRAM REPRESENTATIVES

DR. HUGH K. ROGERS
Director

DR. JON BOTSFORD
Assistant Director

JOE PENICK
Project Coordinator

TERRY SAWMA
Research Coordinator

WALLACE PELTON
Site Coordinator

ROSE MARY TIMMONS
Senior Secretary/Statistician

Furnished By:

MARTY SCHMIDT
Senior Manufacturing Engineer
and Systems Design Engineer

MICHAEL KON
Manufacturing Engineer and
CNC Systems/Program Engineer

Texas State
Technical College
Waco

TRAITS AND ATTITUDES

- Strong Work Ethic
- Interpersonal Skills
- Punctuality
- Dependability
- Honesty
- Neatness
- Safety Conscientious
- Motivation
- Responsible
- Physical Ability
- Professional
- Trustworthy
- Customer Relations
- Personal Ethics

TOOLS AND EQUIPMENT

CURRENT TRENDS/CONCERNS

COMPETENCY PROFILE

Computer Integrated Manufacturing Technician

Prepared By
M.A.S.T.
Machine Tool Advanced Skills
Technology Program
and
Consortium Partners
(V.199J40008)

Texas State
Technical College
Waco

LOCKHEED MARTIN

COMPUTER INTEGRATED MANUFACTURING TECHNICIAN....multi-skilled automation technicians who are capable of installing, integrating, programming, maintaining, diagnosing, repairing, and modifying technologically advanced equipment.

	Duties	Tasks												
A	Use Computers	A-1 Use DOS computer operating systems	A-2 Use OS/2 computer operating systems	A-3 Use UNIX based operating systems	A-4 Use computer inquiry systems	A-5 Use various computer applications								
B	Manage CNC Machine Applications	B-1 Discuss CNC control systems	B-2 Program CNC machines	B-3 Operate CNC machines	B-4 Download/upload CNC programs	B-5 Discuss servo systems theory	B-6 Trouble-shoot CNC hardware and software systems	B-7 Recommend machine interface devices	B-8 Manage preventive maintenance programs	B-9 Recommend machine loading systems				
C	Operate a Computer Aided Design (CAD) System	C-1 Install CAD software on a personal computer	C-2 Create part models using CAD system	C-3 Edit part drawings using a CAD system	C-4 Send drawings to output device	C-5 Convert part drawings via DXF or IGES	C-6 Transfer CAD files to a CAM system							
D	Operate a Computer Aided Manufacturing (CAM) System	D-1 Install CAM software on a personal computer	D-2 Plan machine operations	D-3 Select tools/speeds/feeds for optimum cutting	D-4 Create manufacturing models using a CAM system	D-5 Review part geometry to verify tool path	D-6 Edit models using a CAM system	D-7 Generate CNC code using a CAM system	D-8 Write post processors for a CAM system	D-9 Transfer CAM files to a CAD system				
E	Manage Shop Floor Control Systems	E-1 Install/load SFC software	E-2 Enter job information	E-3 Enter workstation information	E-4 Determine/input run time information	E-5 Inquire as to part routing status	E-6 Compare actual to estimated times	E-7 Evaluate system performance	E-8 Print reports as needed					
F	Monitor Automatic Storage & Retrieval System	F-1 Power up ASRS software	F-2 Verify safety systems are functional	F-3 Consult production reports for stock requirements	F-4 Verify required stock items are present	F-5 Verify stock locations	F-6 Verify accurate bar code placement	F-7 Place the ASRS system online						
G	Manage Robot Applications	G-1 Discuss robot applications	G-2 Identify types of robots	G-3 Determine possible robot applications	G-4 Write robot programs	G-5 Edit robot programs	G-6 Teach robot points with teach pendant	G-7 Appraise robot sensor technologies	G-8 Perform electrical checks for status of discreet input/output connections	G-9 Discuss robotic safety systems				
H	Design Robot Grippers	H-1 Discuss types of robot grippers	H-2 Recommend gripper designs	H-3 Fabricate robot grippers	H-4 Trouble-shoot gripper electro-mechanical systems	H-5 Program robotic gripper operations								
I	Troubleshoot Programmable Logic Controllers	I-1 Write simple ladder logic programs	I-2 Load programs into PLS	I-3 Use PLC software to troubleshoot applications	I-4 Edit PLC programs	I-5 Perform electrical checks for status of input/output signals	I-6 Trouble-shoot electro-mechanical PLC systems							
J	Use Data Communication Systems	J-1 Install computer modem for proper operation	J-2 Install and use data communication software	J-3 Transfer files to a remote computer using a modem	J-4 Receive files from a remote computer using a modem	J-5 Discuss RS-234 interface	J-6 Use data communication system to transfer part information	J-7 Install computer network hardware and software	J-8 Send files using computer network systems					

Duties		Tasks												
K	**Maintain Electrical Devices**	K-1 Use electrical test equipment	K-2 Apply specific terms to electrical circuits	K-3 Analyze series, parallel and complex AC/DC circuits	K-4 Check AC and DC motors	K-5 Inspect transformers and generators	K-6 Discuss sensors and feedback concepts	K-7 Troubleshoot electrical devices						
L	**Maintain Hydraulic and Pneumatic Devices**	L-1 Use test equipment	L-2 Describe basic principles of hydraulic/ pneumatic systems	L-3 Identify hydraulic fluids	L-4 Recommend power distribution and sealing devices	L-5 Recognize pumps, actuators, and control devices	L-6 Troubleshoot hydraulic/ pneumatic systems							
M	**Maintain Machine Vision Systems**	M-1 Discuss machine vision system equipment	M-2 Recommend machine vision system applications	M-3 Perform minor maintenance on machine vision inspection equipment	M-4 Use a light measuring device to verify the proper light levels in the test enclosure	M-5 Perform minor editing of a machine vision inspection program	M-6 Verify proper operation of a machine vision inspection program							
N	**Apply Total Quality and SPC Concepts**	N-1 Define quality in manufacturing and explain importance	N-2 Implement concepts of quality in the workplace	N-3 Apply principles and tools of continuous improvement	N-4 Understand and apply SPC	N-5 Evaluate data to monitor production	N-6 Analyze problems and recommend solutions	N-7 Establish methods, plans, and procedures to maintain quality						

APPENDIX B - PILOT PROGRAM NARRATIVE

What follows is a narrative of the pilot program which was conducted for this particular occupational specialty.

MAST PILOT PROGRAM NARRATIVE: AUTOMATED EQUIPMENT TECHNICIAN/ COMPUTER-INTEGRATED MANUFACTURING

Development of the Pilot Program

The MAST project staff and Associate Professor Douglas Welch at San Diego City College used the skills standards development process, and the industry survey results in particular, to determine the optimal set of skills, knowledge and experience required to be employed in manufacturing as an Automated Equipment Technician/Computer Integrated Manufacturing (CIM) Technician. Professor Welch revised the existing course outlines within the Manufacturing Technology curriculum to address the MAST skill standards and industry findings. Using the standard format adopted by the MAST consortium, Professor Welch incorporated both the technical workplace competencies identified as critical by industry and the SCANS foundation skills and competencies mandated for new training curricula in a growing number of states. In addition, Professor Welch and the CACT staff developed detailed crosswalks matching course objectives against both the technical workplace and SCANS competencies; the course outlines and crosswalks are included elsewhere in this volume.

The AET/CIM Technician pilot program, as taught during the pilot phase of the MAST program consisted of ten college courses supplemented by not-for-credit workshops in SCANS skills. All courses were designed to equip students with the knowledge, skills and competencies to operate, program, and repair automated manufacturing equipment, including computerized numerical control machines (CNC), process control systems, and communication technologies. (Course outlines are included in this volume.) Students enrolled in the fall for a year of training in the facilities of the Center for Applied Competitive Technologies at San Diego City College (CACT-SDCC). The program required 900 hours of student-teacher contact for completion, and classes were six hours per day, four days per week. Nine of the ten courses were taught by Professor Welch . This allowed him to serve as mentor and role model to the students to help to ensure their successful completion of the entire course of study, and to dynamically modify the course content in response to problems or educational opportunities. Students who completed the program received both a Certificate of Completion in Automated Equipment Technology from San Diego City College, and a Certificate of Occupational Competency from the State of California Regional Occupational Program (ROP), the major funding source for the program.

Recruitment And Selection Process

Students were recruited through the California Regional Occupational Program (ROP), which provided county-wide marketing, as well as through the San Diego Community College District's course catalogues and other materials. While College faculty also recruited students throughout the County's public secondary school system, primarily through job fairs and school-to-career committees, the majority of the program students were unemployed workers seeking to upgrade their skills for today's job market. The fastest growing source of program recruitment appeared to be informal referrals by local companies who knew of the program and recommended it to current or prospective employees. A total of 38 students enrolled in the pilot program.

The AET/CIM program was open to all qualified applicants. Students were required to meet with faculty before enrollment, during a series of orientation sessions held during the summer, to discuss their career goals and review assessment scores. In these sessions students were informed as to the financial requirements for the program, course completion schedules, enrollment procedures, and minimum skill requirements. Students with poor reading or math skills were encouraged to take remedial courses before enrollment. It was not uncommon for students who scored low in one category to be admitted based on the student's willingness to address specified academic barriers.

Industry and Secondary School Participation

No formal apprenticeship program is tied to the AET/CIM program, but a number of informal relationships with local companies provide a strong source of internship opportunities. Hewlett Packard, Sony, NASSCO, and Solar Turbines all have hired graduates and often refer potential students to the program for training. Coca-Cola has begun to recruit Automated Equipment Technicians for their process plants, and there has been discussions with the San Diego Light Rail (San Diego Trolley) system and Solar Turbines Inc. regarding potential development of apprenticeship programs with the College. The fortunate co-tenantship of the San Diego High Technology Incubator, housed in the same building and managed by the CACT, provides a source of internships for graduating students during the summer. One Incubator firm, Strain Monitor Systems, asked students to help install and set-up their hydraulic and heating test systems to be used to test their product in the coming year, an exchange that benefitted both parties. Another Incubator firm involved students in a project to solve problems in stepper motor motion control, requiring the class to generate a series of engineering reports and suggest various solutions for the company.

Final Evaluation of the Pilot Program

A total of 38 students enrolled in the pilot and 26 completed the entire program. Of the 26 who completed the program 2 failed to obtain competency for all of the sections. Competency was determined by factors other than test scores. For example, mastery of lab procedures and team work was a significant factor in determining competency. Below are the pre- and post-test score results of completing students by demographic category:

Category	# of Students	Pre-/Post-test	
		Entry	Exit
Single head of household	7	58%	76%
Single parent	3	55%	75%
Disability	5	56%	76%
Economically disadvantaged	13	55%	75%
Non-traditional occupation	12	57%	77%

Note: There is some duplication of students across categories.

Demographics were determined by information sheets filled out by applicants. A sample sheet is included for reference

Some students do not belong to any of the above categories

The final evaluation tests were a series of eight tests based on the final exam for eight of the pilot program courses. Two of the ten courses, the machine shop course, and the flexible manufacturing course, are competency based and do not incorporate final exams. Administered as a pre-test at the beginning of each course, the exams were modified - e.g., values and possible answers changed, the same concept approached from a different perspective -- to serve as the final exam. Copies of the tests are included in this section. The test results reflect the fact that some exam material may have been mastered in earlier classes as a result of deliberate overlap in course material. For example, concepts from the physics section and drawing interpretation class are applicable to the hydraulics/pneumatics section, and questions on the hydraulics/pneumatics test can be answered from this material. The results are a cumulative score over a series of eight tests, and therefore do not reflect improvement in individual skill areas. Test results are average scores for the twenty-six students who completed the program; of these, 98% increased their scores by more than 20% from pre- to post-test, 60% scored above the 75th percentile, and 70% scored above the 70th.
percentile. A score below 65% indicated a lack of competency for that course section.

Conclusions

The MAST project enhanced the focus and relevance of the AET/CIM program considerably. The process of developing the skill standards helped to ensure that all classes meet industry requirements and have well defined goals and outcomes. The process of industrial validation of the skill standards created opportunities to inform companies of the supply of trained workers available through the program. The relationships formed with federal labs and other manufacturing facilities provided valuable information regarding the applicability of the program technologies to unusual situations and non-traditional job opportunities. Finally, instructors have revised upward their expectations regarding the ability of students to assimilate complex technologies and modified the courses accordingly to incorporate the additional complexity.

The project also changed student attitudes toward their career choices and prospects. One student who had worked as construction electrician for a shipbuilder advanced to CNC technician. Another student employed as a furnace operator was offered a job as engineering technician with Parker-Hannifin. At least two students who dropped out before completing the pilot were lured away by attractive job offers, one accepting a position as supervisor at an automated plastics manufacturer and the second hired as a systems integrator for AT&T. Perhaps most significantly, at least a third of the class has taken the Manufacturing Technologist exam from the Society of Manufacturing Engineers (SME) and about that many are preparing to test as Certified Electronics Technician (CET).

Statistics for students in pilot program

Roster	Single Head of Household	Single Parent	Disability	Economically Disadvantaged	Non Trad-itional
Aeillo, Steve	yes		yes	yes	yes
Akiwowo, Peter			yes	yes	yes
Andrus, Dale					
Aquino, Reggie	yes	yes		yes	yes
Betts, Brian				yes	
Cruz, Ernesto					yes
Edilloran, Nestor					yes
Erickson, William					
Esteban, Jonathan	yes			yes	yes
Galvin, Greg					
Honarvar, Jeff					
Houchen, James				yes	
Kroneheimer, David					yes
Lauria, Frank				yes	
Lohouse, Brian					
Merritt, Scott	yes		yes	yes	
Montalvo, Cynthia	yes			yes	yes
Nguyen, Sonny					
Nichols, Nick			yes	yes	
Nichols, Nidia			yes	yes	yes
Nielsen, Gerry	yes	yes			
O'Hare, Henry					
Ona, Ellen				yes	yes
Perez, Claudia	yes			yes	yes
Saldaen, Sammy					yes
Salomon, Jose					yes
Totals	7	3	5	13	13

Entry/Exit scores by category (all scores are in percentages)

		Single Head of Household	Single Parent	Disability	Economically Disadvantaged	Non Trad-itional
Average	Entry	58.00	55.00	56.00	55.00	57.00
Average	Exit	76.00	75.00	76.00	75.00	77.00

NON-traditional categories	
Pacific Islander	1
African American	1
Filipino	5
Hispanic	2
Female Hispanic	3
Female White	1
total	13
8 of the 10 courses were evaluated	
One of the courses not evaluated -Manufacturing Technology 220	
One course is project only - Manufacturing Technology 225	

1. La amily) Name

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z (in each of 18 columns)

2. First Name & Initial

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z (in each of 11 columns)

3. Print ROP se Title

4. Cours Section(s)

Course					Section			Section		
0	0	0	0	0	C	0	0	C	0	0
1	1	1	1	1	F	1	1	F	1	1
2	2	2	2	2	M	2	2	M	2	2
3	3	3	3	3	S	3	3	S	3	3
4	4	4	4	4	T	4	4	T	4	4
5	5	5	5	5	X	5	5	X	5	5
6	6	6	6	6	Y	6	6	Y	6	6
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San Diego County Regional Occupational Program

REG

INSTRUCTIONS

This form registers you for enrollment in an ROP class. Please help us by filling out sections 1-30 carefully and completely. Please use a Number 2 pencil only.

1. In the sections to the left, print your last name, first name, and initial. Then darken the corresponding ovals below each letter. In the same way, mark the remaining sections on this side of the form.
2. Turn the form over. Enter your mailing address, city name, and ZIP code. Darken the corresponding ovals. Complete the rest of the sections on the back.
3. Sign your name on the line provided on the back and return this form to the registration staff.

You will not be excluded from an ROP course due to your responses on this form. Shaded questions apply to adults only. Thank you.

5. ROP USE ONLY

Month	Day		H	Min	
Jan ○			8		
Feb ○			9		
Mar ○	0	0	10	00	0
Apr ○	10	1	11	10	1
May ○	20	2	12	20	2
Jun ○	30	3	1	30	3
Jul ○		4	2	40	4
Aug ○		5	3	50	5
Sep ○		6	4		6
Oct ○		7	5		7
Nov ○		8	6		8
Dec ○		9	7		9

6. Why are you taking this class? (mark one)

A ○ Prepare for a job
B ○ Upgrade existing skills
C ○ Prepare for further training
D ○ Other: ____________

San Diego County ROP Regional Occupational Program
Quality Job Preparation

7. Mark one

F ○ Female
M ○ Male

8. Ethnic Origin (mark one)

I ○ American Indian
I ○ Alaskan Native
A ○ Asian
P ○ Pacific Islander
F ○ Filipino
H ○ Hispanic
B ○ Black (not Hispanic)
W ○ White (not Hispanic)

9. Birth Date

Month	Day		Year	
Jan ○				
Feb ○				
Mar ○	0	0	00	0
Apr ○	10	1	10	1
May ○	20	2	20	2
Jun ○	30	3	30	3
Jul ○		4	40	4
Aug ○		5	50	5
Sep ○		6	60	6
Oct ○		7	70	7
Nov ○		8	80	8
Dec ○		9	90	9

10. Social Security Number

0 1 2 3 4 5 6 7 8 9 (in each of 9 columns)

11. Home Telephone

619 ○
714 ○
909 ○

0 1 2 3 4 5 6 7 8 9 (in each of 7 columns)

12. Emergency Telephone

619 ○
714 ○
909 ○

0 1 2 3 4 5 6 7 8 9 (in each of 7 columns)

13. Where did you learn about ROP? (mark one only)

A ○ Counselor
B ○ Teacher / ROP Instructor
C ○ Career center
D ○ Local newspaper
E ○ Radio / TV
F ○ School mailing
G ○ Brochure / handbook
H ○ Friend / relative
I ○ Place of employment
J ○ Advertising bulletin (e.g. PennySaver)

14. Is it difficult for you to speak, read, or write English because it is not your native language?

○ Yes ○ No

NOTE

Make dark marks that completely fill the ovals, like this: ●

Rev 9/94

Please continue on other side: →

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15. Your mailing address

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16. Print your city name

17. ZIP

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18. If you are enrolled in a school other than high school, please indicate which type(s) of school (mark all that apply)

A ○ Adult school
B ○ Community college
C ○ Four-year college or university
D ○ Vocational or trade school
E ○ ROP
○ None

19. Are you enrolled in any of the following training programs? (mark all that apply)

A ○ Articulated with College
B ○ Tech prep
C ○ Academy
D ○ Apprenticeship
○ None

20. Are you currently participating in any of these programs? (mark all that apply)

A ○ AFDC–Aid to Families with Dependent Children
B ○ GAIN–Greater Avenues to Independence (workfare)
C ○ Unemployment, Welfare, or General Assistance
D ○ JTPA–Job Training Partnership Program
E ○ Supplemental Social Security (including Disability)
F ○ Job Corps / JOBS Program
G ○ Pell Grant
H ○ BOGG–Board of Governors Grant
○ None

21. Academic Special Needs (mark one)

A ○ Disadvantaged
B ○ Limited English
C ○ Learning disabled
○ None

22. Economic Special Needs (mark one)

A ○ Disadvantaged
B ○ Single parent
C ○ Displaced homemaker
D ○ Single pregnant woman
E ○ Single head of household
○ None

23. What's the highest level of education you have completed? (mark one)

A ○ Currently enrolled in high school →
B ○ Some high school, no diploma
C ○ High school graduate or GED
D ○ Some college
E ○ Associate degree
F ○ Bachelor degree
G ○ Graduate degree

24. Current grade level

○ 9th grade
○ 10th grade
○ 11th grade
○ 12th grade

Print name of your high school below:

25. Marital Status

S ○ Single
M ○ Married

26. How may financial dependents do you have?

1 ○ One
2 ○ Two
3 ○ Three
4 ○ Four
5 ○ Five or more
0 ○ None

27. Annual household income level (mark one)

00 ○ $7,500 or less
07 ○ $7,501 – 8,500
08 ○ $8,501 – $9,500
09 ○ $9,501 – 10,500
10 ○ $10,501 – 11,500
11 ○ $11,501 – 15,000
15 ○ $15,001 – 16,000
16 ○ $16,001 – 17,000
17 ○ $17,001 – 18,000
18 ○ $18,001 – 19,000
19 ○ over $19,000

28. Currently employed?

○ Yes
○ No

29. Most significant disability (mark one)

10 ○ Hearing impaired
15 ○ Deaf
20 ○ Deaf / Blind
25 ○ Visually impaired
30 ○ Speech impaired
40 ○ Orthopedic
45 ○ Other Health
60 ○ Mental
70 ○ Emotional
80 ○ Learning
90 ○ Multiple disabilities
00 ○ None

ROP USE ONLY

229

35. Site Code

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㉚ Student's Signature:

BEST COPY AVAILABLE

I understand that my enrollment and attendance in this ROP class depend on my abili enefit from the program. This will be determined by the County

㉛ Staff Signature:

㉜ Phone:

㉝ Date

34. ○ Approved ○ Waitlist

Manufacturing Technology 100 Final Exam

Scientific Notation

1. Express .00001 in scientific notation

a. 1.0×10^{-9}
b. 1.0×10^{5}
c. 1.0×10^{-5}
d. 1.0×10^{-4}

2. Express .0047 in scientific notation

a. 4.7×10^{-3}
b. 47×10^{-4}
c. $.47 \times 10^{-2}$
d. 47×10^{-3}

3. Express 33,000 in scientific notation

a. 33×10^{3}
b. 3.3×10^{4}
c. 3.3×10^{3}
d. $.33 \times 10^{5}$

4. Express 1,200,000 in scientific notation

a. 1.2×10^{7}
b. 1.2×10^{5}
c. 12×10^{6}
d. 1.2×10^{6}

5. Perform the following calculation using scientific notation. Express the answer in scientific notation. 470 x .000001

a. 4.7×10^{-5}
b. $.47 \times 10^{-4}$
c. 4.7×10^{-4}
d. 47×10^{-4}

6. Perform the following calculation using scientific notation. Express the answer in scientific notation. 10 / .000025

a. 4.0×10^{6}
b. 4.0×10^{3}
c. $.4 \times 10^{5}$
d. 4.0×10^{5}

7. Perform the following calculation using scientific notation. Express the answer in scientific notation. 200 / 5,000

a. $.4 \times 10^{-2}$
b. 4.0×10^{-2}
c. 4.0×10^{-3}
d. 40×10^{-2}

8. Perform the following calculation using scientific notation. Express the answer in scientific notation. .5 x 15000

a. 7.5×10^{2}
b. 7×10^{3}
c. 7.5×10^{3}
d. 75×10^{3}

Engineering Notation

9. Express the following number in engineering notation. .0000047

a. 47 u
b. 4.7 n
c. .47 u
d. 4.7 u

10. Express the following number in engineering notation. 15,000,000

a. 1.5 M
b. 15 M
c. .15 M
d. 150 k

11. Express the following number in engineering notation. .00022

a. 220 u
b. 2.2 u
c. 220 n
d. 220 m

12. Express the following number in engineering notation. 68,000

a. 68 M
b. 680 k
c. 68 k
d. .68 M

13. Perform the following operation using engineering notation. Express the answer in engineering notation.

2. 2M /22 k

a. 1 k
b. 1
c. 11 k
d. 100

14. Perform the following operation using engineering notation. Express the answer in engineering notation.

33 u /3.3 m

a. 10 u
b. 1000 m
c. 10 m
d. 1.0×10^{-4}

15. Perform the following operation using engineering notation. Express the answer in engineering notation.

560k / 5.6 k

a. 100
b. 10
c. 1 k
d. 1

16. Perform the following operation using engineering notation. Express the answer in engineering notation.

670 k x 2.2 u

a. 1.47 k
b. 1.474
c. 1.47 u
d. 14.7

Exponents

In the following problems, a =3 , b = 1 , c = -6 , d = -3 Perform the indicated exponential operations

17. $y^a \times y^d =$

a. 1
b. 0
c. y^{-6}
d. y

18. x^a / x^d

a. x^{-3}
b. 0
c. x^6
d. x^7

19. $(x^a)^a * x^c$

a. x^{-3}
b. x^3
c. x^{-4}
d. x^4

20. $(y^d)^a/y^d$

a. y^{-4}
b. y^6
c. y^5
d. y^{-3}

Polynomials Simplify the following:

21. $3a^2 - 7a^2 + 6a - 4a$

a. $-4a^2+2a$
b. $4a^2+a$
c. $-10a^2+10a$
d. $3a^2+2a$

22. $(2a - 2b + 7) + (2a - 2b - 3)$

a. $4a-b+4$
b. $4a-4b+4$
c. $4a-4b+10$
d. $4a-4b$

23. $(4x - 8y) - (5x + 3y - 4)$

a. $x - 5y+4$
b. $-x - 5y$
c. $9x - 5y+4$
d. $-x - 5y+4$

24. $4a - 3b - 6a - 2b + 3a + 6b$

a. $7a+9b$
b. $7a+b$
c. $a+9b$
d. $a+b$

Multiply the following polynomials

25. $-5x(-2x -8)$

a. $-10x^2+40x$
b. $10x^2- 40x$
c. $10x^2+40x$
d. $-10x^2-40x$

26. $(3a - 5)(4a -6)$

a. $12a^2-38a+30$
b. $12a^2+38a-30$
c. $12a^2-2a+30$
d. $12a^2+30$

27. $(x - y + 5)(x - y)$

a. $x^2-5x-5y+y^2$
b. $x^2-2xy+5x-5y+y^2$
c. $x^2-2xy+5y+y^2$
d. $x^2-2xy+y^2$

28. $(x - y + 1)(x + y - 1)$

a. $x^2 + 2y - 1 - y^2$
b. $x^2 + 2y - y^2$
c. $x^2 - y^2$
d. $x^2 + 2y - 1$

Fully factor the following expressions

29. $4x-x^2+xy$

a. $x(4x-x+y)$
b. $y(4x-x^2+x)$
c. $x(4-x+y)$
d. $x^2(4-y)$

30. $36x^2y^2-48xy+24x^3y^3$

a. $12xy(3xy-4+2x^2y^2)$
b. $3[2\{(2xy(3xy-4+2x^2y^2)\}]$
c. $12xy(3x^2y^2-4+2x^2y^2)\}]$
d. $3[2\{(2xy(3xy-4xy+2x^2y^2)\}]$

31. $36x^2y-47y+25x^3y^3$

a. $y(36x^2-47+25x^3y^2)$
b. $2y(18x^2-4+25x^3y^2)$
c. $y(36x^2-47+25xy)$
d. $y(36x-47+25xy)$

32. $4x^2 - 25$

a. $(2x + 5)\ (2x + 5)$
b. $(2x + 5)\ (2x - 5)$
c. $(2x - 5)^2$
d. $(2x + 5)^2$

Divide the following polynomials.

33. $85x^4\ y^2/17x\ y$

a. $5x^3y^2$
b. $4x^3y$
c. $5x^2y$
d. $5x^3y$

34. $x^2 - 5x - 6/x + 1$

a. $x - 6$ $R=1/x-6$
b. $x - 6$
c. $x - 3$
d. $x + 3$

35. $-6x^2\ y/3xy$

a. $-2x$
b. $-2x^2$
c. $2x$
d. $-2xy$

36. $3x^2 - 2x - 3/x - 2$

a. $3x + 4$ R $5/x-2$
b. $3x + 4$
c. $3x - 4$
d. $x + 4$ R $1/x-2$

Formulas

37. In the formula $F = P * A$, A varies __________ with F

a. directly
b. inversely

38. In the formula $I = V / R$, I varies ___________ with R

a. directly
b. inversely

39. In the formula $X_C=1/2\pi fC$, $X_C$varies ________ with f

a. directly
b. inversely

40. Using the formula for inductive reactance, $X_L=2\pi fL$, find the value of L if $X_L = 1000$ ohms, and f = 10 k Hz

a. 160 mHy
b. .16 mHy
c. 16 mHy
d. 10 mHy

41. Using the formula for capacitive reactance, $X_C=1/2\pi fC$, find the value of C if $X_C = 10$ ohms, and f = 1 k Hz

a. 1.6 ufd
b. 16 ufd
c. 160 ufd
d. .16 ufd

42. Using the formula for Impulse Momentum, Ft=mV, find the value of V if F = 980 Newtons, mass = 100 Kg and t = .1 sec. for a mass brought to a complete stop. (F=ma)

a. 100 Kg*m/sec
b. 9.8 Kg*m/sec
c. 98 Kg*m/sec
d. 1 Kg*m/sec

Equations: Solve the following equations for the given variable.

43. $A = P + Prt$ (solve for r)

a. $A/Pt-P= r$
b. $(A-P)/Pt = r$
c. $(A-1)/t-P = r$
d. $(A-Pt)/P = r$

44. $P = 2(e + w)$ (solve for e)

a. $(P/2)-w = e$
b. $P/(2-w) = e$
c. $P-w = e$
d. $2(P-w) = e$

45. $$R_T = \frac{R_1 * R_2}{R_1 + R_2}$$ (solve for R_1)

a. $R_1=(R_T*R_2)/R_T-R_T$
b. $R_1=(R_T*R_2)/R_T-R_2$
c. $R_1=(R_T*R_2)/-R_2-R_T$
d. $R_1=(R_T*R_2)/R_2-R_T$

Find the value of the x variable for the following equations.

46. $4(x - 3)= 3(10 - x)$

a. $x=7$
b. $x=1$
c. $x=6$
d. $x=3/10$

47. $8x / 25 = 8$

a. $x=5$
b. $x=25$
c. $x=20$
d. $x=40$

48. $3x / 4 +1 = x / 8$

a. $x=1$
b. $x=2$
c. $x=1\ 1/2$
d. $x=-1\ 3/5$

49. $4 - 3x = 31$

a. $x=9$
b. $x=-9$
c. $x=-18$
d. $x=13$

50. Word problem: The total resistance in a series/parallel circuit is twice the value of the sum of two of the series resistors. If the circuit consists of two series resistors and a parallel branch consisting of three equal resistors in parallel, and if the value of ONE of the parallel resistors is 33 k ohms, and the smaller of the two series resistors is one tenth of the value of the other series resistor, what is the value of the smaller of the series resistors.

a. 2 kΩ
b. 11 kΩ
c. 1 kΩ
d. 10 kΩ

51. Word problem: If a 50 amp circuit breaker which is sourcing a 24 VDC source, trips repeatedly after being reset, what is the MAXIMUM resistance of the load? (assume that the breaker trips on a current that is 150% of the rating of the circuit breaker). (Voltage = Current (amps)*Resistance)

a. 32 Ω
b. 50 Ω
c. .5 Ω
d. .32 Ω

Using any method, solve the following equations.

52. $2x = -64$

a. $x = 32$
b. $x = -8$
c. $x = -32$
d. $x = 0$

53. $3x-5=4x+32$
a. $x = 37$
b. $x =-27$
c. $x =5\ 2/7$
d. $x =-37$

54. $16x - 8x - 10 = 0$

a. $x = -2$
b. $x = 25$
c. $x = 2$
d. $x = -10$

55. In a series electrical circuit the power (P) dissipated in R_1 is 5 milli watts, the voltage (V) dropped across R_2 is 1 volt, and the resistance of R_3 is 2k Ω. If the source voltage is 8 volts, what is the value of R_T? ($P=I^2*R$, $V=I*R$)

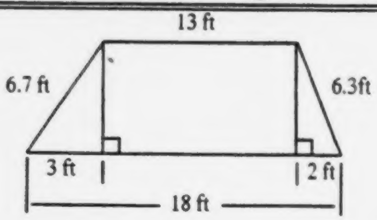
a. 1 k Ω
b. 5 k Ω
c. 8 k Ω
d. 200 Ω

Plane Geometry

56. Find the area of a rectangle 19 CM long and 16 cm wide.

a. 205 cm^2
b. 400 cm^2
c. 403 cm^2
d. 304 cm^2

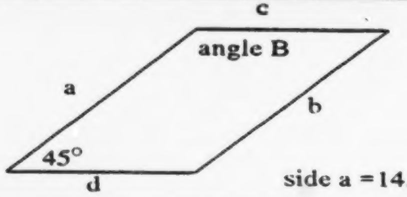
Given the figure below, find the height and the area.



57. height =, area =

a. 6 ft, 93 ft^2
b. 7 ft, 90 ft^2
c. 5 ft, 90 ft^2
d. 6 ft, 80 ft^2

Given the parallelogram below, find the perimeter and the area

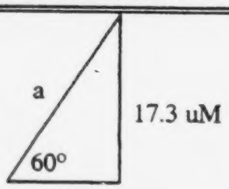


side a =14.14 in angle B= 135°

58. perimeter =, area =

a. 50 in, 100 in^2
b. 48.28 in, 10 in^2
c. 48.28 in, 100 in^2
d. 50 in, 50 in^2

Given the figure below, find the length of side a and the area



59. side a =, Area=

a. 10 uM, 30 uM^2
b. 20 uM, 86.5 uM^2
c. 30 uM, 186.5 uM^2
d. 20 uM, 186.5 uM^2

Given a circle of 20 cm diameter, find the circumference and the area.

60. circumference =, area=

a. 31.14 cm, 314.2 cm^2
b. 62.83 cm, 628.4 cm^2
c. 40 cm, 628.4 cm^2
d. 62.83 cm, 314.2 cm^2

Solid Geometry

61. Find the volume of a right prism with dimensions of 18 cm by 12 cm by 20 cm.

a. 432 cm^3
b. 4320 cm^3
c. 320 cm^3
d. 203 cm^3

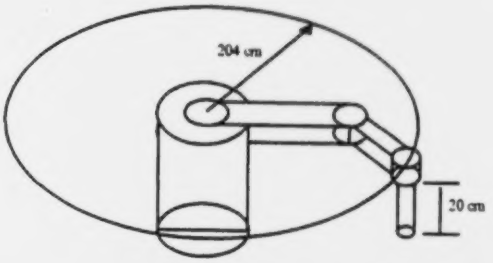
62. Find the volume of a cylinder that has a circumference of 125.67 cm and is 60 cm in height.

a. 75398.2 cm^3
b. 5398.2 cm^3
c. 7398.2 cm^3
d. 753980.2 cm^3

63. In the above cylinder, what is its total surface area ?

a. 7540.2 cm^2
b. 7398.2 cm^2
c. 8796.77 cm^2
d. 10053.47 cm^2

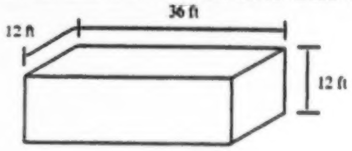
A SCARA robot is to be placed in a work cell. If the furthest extension of the robot is 204 cm , the movement of the Z axis (perpendicular to the extension) is 20 cm, what is the work envelope of the robot?



64. Work envelope=

a. 2.615 x 10^6 cm^3
b. 2.615 x 10^3 cm^3
c. 2.615 x 10^5 cm^3
d. 600 x 10^6 cm^3

65. Find the volume of the furnace interior below



a. 6184 ft^3
b. 5184 ft^3
c. 15184 ft^3
d. 8145 ft^3

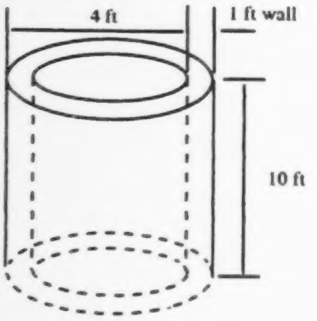
Find the surface area and volume of one half of a sphere that a has a aradius of 2 cm.

66. surface area =, volume =

a. 12.13 cm^2, 16.755 cm^3
b. 25.13 cm^3, 16.755 cm^2
c. 25.13 cm^2, 16.755 cm^3

d. 25.13 cm^2, 16.755 cm^3

67. A steel container must be moved with a crane. If the container is a cylinder ,and steel weighs .28 pounds per in^3, what is the weight of the steel?



a. 243204.5 lbs
b. 60801.13 lbs
c. 95001.76 lbs
d. 121602 ibs

Trignometry

68. **Find each of the following:**
cos 30 degrees, sin 60 degrees , tan 45 degrees

a. .5, .5, 1.73
b. .886, .866, 1
c. .954, .531, 57.29
d. .3142, .657, 60.19

69. **Find each of the following:**
cos 60 degrees, sin 30 degrees , tan 60 degrees

a. .5, .5, 1.73
b. .886, .866, 1
c. .954, .531, 57.29
d. .3142, .657, 60.19

70. **Find each of the following:**
cos 17.5 degrees, sin 32.1 degrees , tan 89 degrees

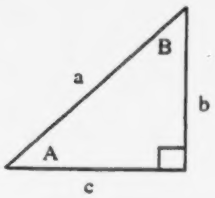
a. .5, .5, 1.73
b. .954, .531, 57.29
c. .886, .866, 1
d. .3142, .657, 60.19

71. Find each of the angles
sin A =. 651, tan B = 31.2, cos A =. 6589

a. 45°, 26.57°, 45°
b. 88.16°, 26.57°, 45°
c. 40.62°, 88.16°, 48.78°
d. 45°, 48.78°, 26.57°

72. Find each of the angles
sin A =. 707, tan B = .5, cos A =. 707

a. 45°, 26.57°, 45°
b. 40.62°, 88.16°, 48.78°
c. 45°, 48.78°, 26.57°
d. 88.16°, 26.57°, 45°



73. In the above diagram, if angle A is 50 degrees, and side c is 40 inches, what is the length of side a?

a. 30.64 inches
b. 62.22 inches
c. 47.67 inches
d. 25.71 inches

74. In the above diagram, if angle B is 41 degrees, and side c is 50 cm, what is the length of side a?

a. 32.8 cm
b. 37.77 cm
c. 43.46 cm
d. 76.21 cm

75. In the above diagram, if side c is 10 inches, and side b is 15 inches, what is the value of angle B?

a. 56.31°
b. 33.69°
c. 41.8°
d. 48.19°

76. In the above diagram, if angle A is 50 degrees, and side a is 40 inches, what is the length of side b?

a. 62.22 inches
b. 30.64 inches
c. 47.67 inches
d. 25.71 inches

77. In the above diagram, if angle B is 45 degrees, and side a is 35 inches, what is the length of side c?

a. 24.75 inches
b. 49.5 inches
c. 35 inches
d. 40 inches

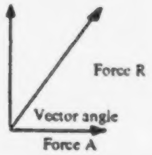
78. In the above diagram, if angle A is 60 degrees, and side c is 40 inches, what is the length of side b?

a. 34.64 inches
b. 69.22 inches
c. 20 inches
d. 35 inches

79. If the inductive reactance of a series R-L circuit is 75 ohms, and the resistance is 125 ohms, find the impedance and phase angle.

a. 145.8 ohms, 30.1°
b. 45 ohms, 60.1°
c. 235.1 ohms 45°
d. 129.3 ohms 50°

80. If the resultant of two vectored forces acting at right angles is 70 Newtons, and force A is 30 Newtons, what is the angle of the resultant vector from force A?



a. 64.6°
b. 25.4°
c. 15.7°
d. 35.4°

Graphing Equations

81. What is the y intercept point of the equation 3x-1/2=y?

a. 3
b. 1/3
c. 3/4
d. 1/2

82. What is the slope of the equation 3/4x-6=y?

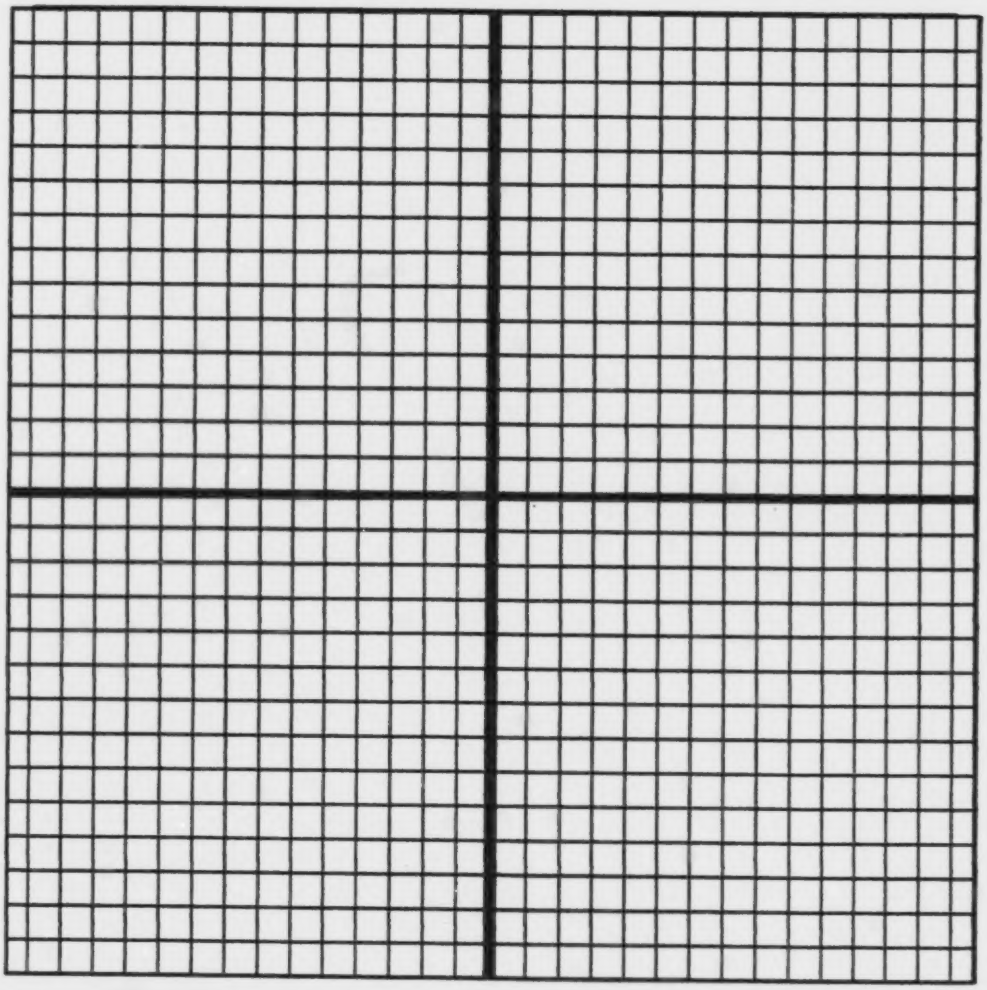
a. y = 3, x = 4
b. y = 4, x = 3
c. y = 6, x = -1
d. y = -1, x = 6

83. **Based upon the concept of slope, Do the equations $2x-3=y$ and $-1/3x+6=y$ have a common solution?**

a. yes
b. no

84. **Based upon the concept of slope, Do the equations $2x+4=y$ and $2x-3=y$ have a common solution?**

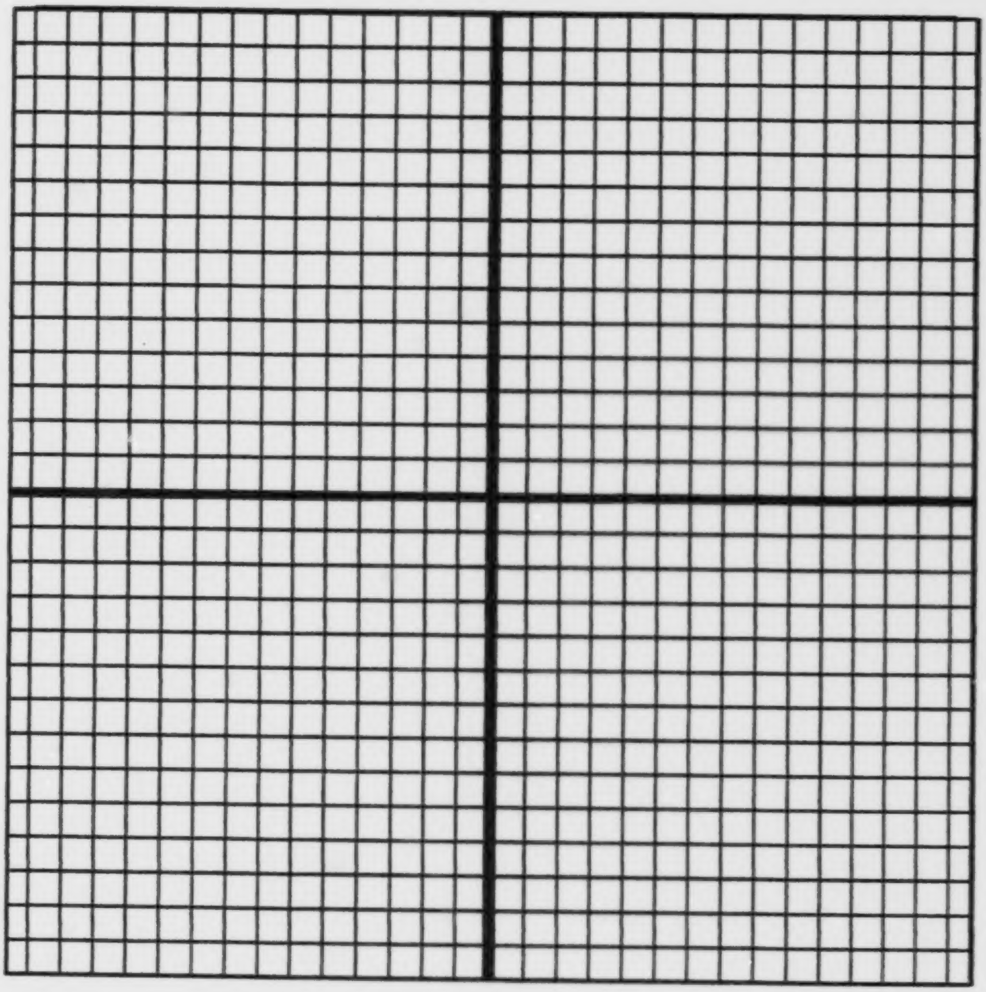
a. yes
b. no



85. (5 points) Draw the graph of $3x - 3 = y$. Lable the y intercept point, and determine the slope.

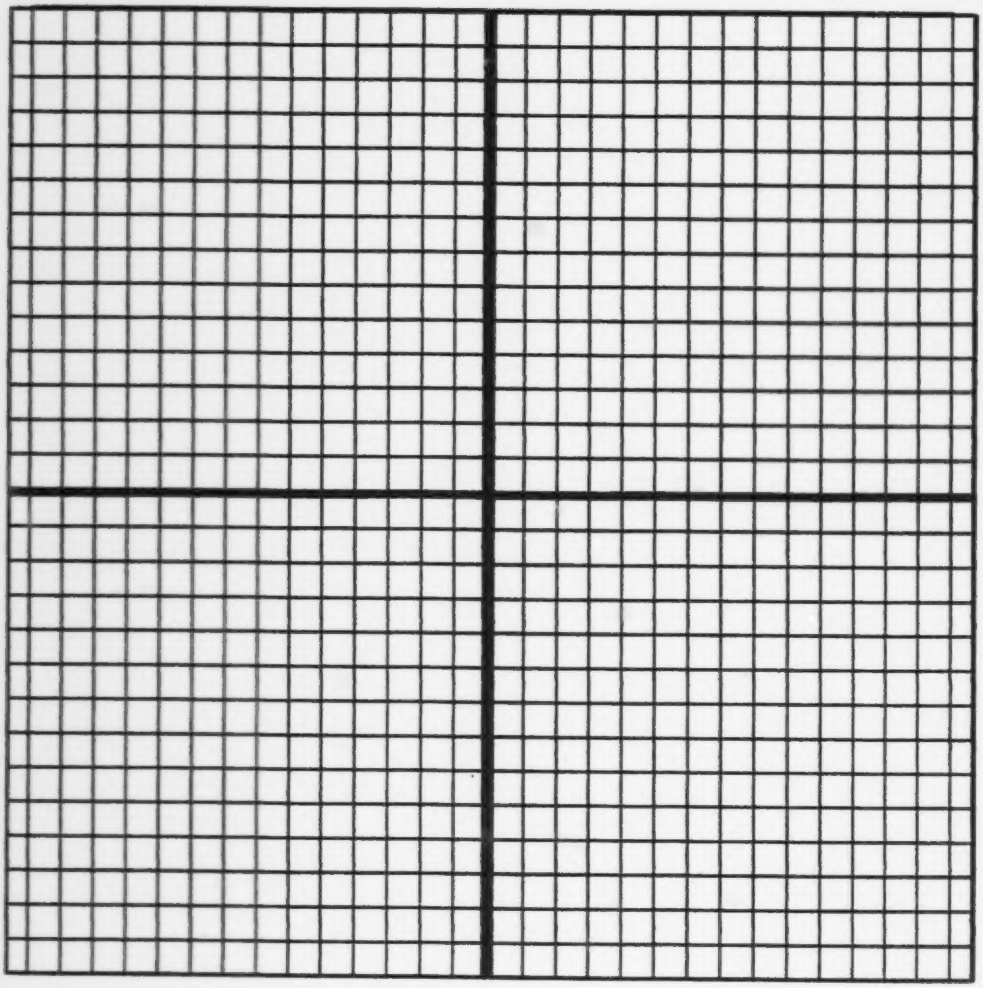
y intercept =

Slope =



86. (5 points) On one graph, draw the lines of $3x + 5 = y$ and $-2x = y$. Lable the point at which there is a common solution for both equations.

Common solution point=



87. (5 points) Draw the graph of the equation -5/6x-3=y. Calculate the y intercept point and the slope.

y intercept =

Slope =

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Mechanical Drawings

For the next 11 questions, choose from the below list:

A - Extension line
B - Leader line
C - Dimension line
D - Section line
E - Viewing or cutting plane line
F - Center line
G - Hidden line
H - Break line
I - Circular line
J - Feature line or visable line
K - Phantom line

1. Item 1 on drawing 1 is:

a. A
b. E
c. D
d. K

2. Item 2 on drawing 1 is:

a. A
b. E
c. G
d. K

3. Item 3 on drawing 1 is:

a. I
b. C
c. H
d. G

4. Item 4 on drawing 1 is:

a. J
b. G
c. F
d. K

5. Item 5 on drawing 1 is:
a. E
b. K
c. G
d. J

6. Item 6 on drawing 1 is:

a. J
b. H
c. C
d. I

7 Item 7 on drawing 1 is:

a. J
b. B
c. K
d. F

8. Item 8 on drawing 1 is:

a. C
b. A
c. K
d. B

9. Item 9 on drawing 1 is:

a. J
b. E
c. B
d. F

10. Item 10 on drawing 1 is:

a. E
b. D
c. B
d. F

11. Item 11 on drawing 1 is:

a. K
b. E
c. None of the above
d. B

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For the next 8 questions, choose from the below list:

A - Perpendicularity
B - Straightness
C - Flatness
D - Position
E - Parallelism
F - Circular Runout
G - Diameter
H - Maximum material condition
I - Feature control frame
J - Datum Feature
K - Total runout
L - Basic Dimension

12. Symbol 1 on drawing 2 is:

a. L
b. C
c. A
d. E

13. Symbol 2 on drawing 2 is:

a. E
b. A
c. D
d. J

14. Symbol 3 on drawing 2 is:

a. G
b. B
c. L
d. I

15. Symbol 4 on drawing 2 is:

a. A
b. F
c. C
d. H

16. Symbol 5 on drawing 2 is:

a. D
b. A
c. I
d. C

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17. Symbol 6 on drawing 2 is:

a. A
b. H
c. L
d. K

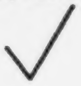
18. Symbol 7 on drawing 2 is:

a. I
b. B
c. A
d. J

19. Symbol 8 on drawing 2 is:

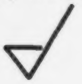
a. I
b. E
c. J
d. A

20. In mechanical drawings, the below symbol stands for:



a. Square root
b. perpendicularity
c. surface finish
d. projected tolerance zone

21. In mechanical drawings, the below symbol stands for:



a. protected finish
b. machining perpendicularity
c. surface finish, material removal by machining required
d. projected tolerance zone angle

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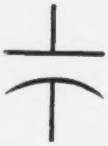
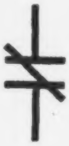
Electrical/Electronic Symbols and Ladder Diagrams

22. The below symbol represents:



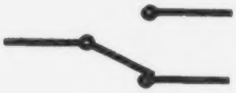
a. A set of normally open contacts
b. A capacitor
c. A set of normally closed contacts
d. A DC source

23. The below symbol represents:



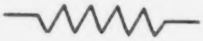
a. A set of normally open contacts
b. A set of normally closed contacts
c. A non polarized capacitor
d. An electolytic capacitor

24. The below symbol represents



a. A SPDT switch
b. A DPDT switch
C. A TPTT switch
d. A DPST switch

25. The below symbol represents



a. A resistor
b. An inductor
c. A transformer
d. A potentiometer

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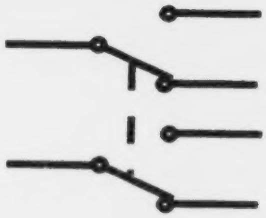
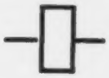
26. The below symbol represents



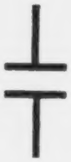
a. A SPDT switch
b. A DPDT switch
c. A SPST switch
d. A multi-position switch

27. The below symbol represents:



a. The coil of a relay or solenoid
b. A capacitor
c. A set of normally closed contacts
d. A potentiometer

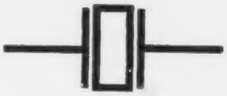
28. The below symbol represents:



a. A set of normally open contacts
b. A set of normally closed contacts
c. A non polarized capacitor
d. An electolytic Capacitor

Electrical/Electronic Symbols and Ladder Diagrams

29. The below symbol represents



a. A three pole circuit breaker
b. A DPDT switch)
c. A single pole circuit breaker
d. A crystal

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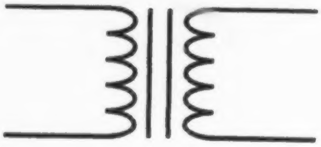
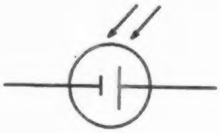
30. The below symbol represents



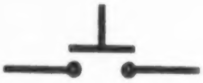
a. An air core transformer
b. An inductor
c. An iron core transformer
d. A potentiometer

31. The below symbol represents



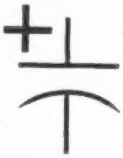
a. A capacitor
b. A crystal
c. A solar cell
d. A lamp

32. The below symbol represents:



a. A set of normally open contacts
b. A set of normally closed contacts
c. A normally open push button switch
d. An electolytic capacitor

33. The below symbol represents:



a. A set of normally open contacts
b. A set of normally closed contacts
c. A non polarized Capacitor
d. An electolytic capacitor

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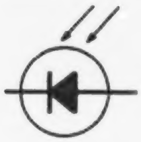
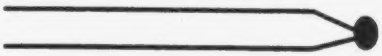
34. The below symbol represents



a. A thermistor
b. A varistor
c. A photo diode
d. A light emitting diode

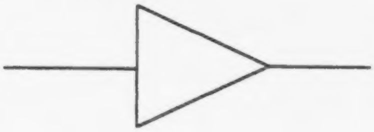
35. The below symbol represents



a. A connector
b. A thermocouple
c. A conductor
d. An insulator

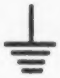
Electrical/Electronic Symbols and Ladder Diagrams

36. The below symbol represents



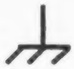
a. An amplifier
b. A relay coil
c. A solar cell
d. A conductor

37. The below symbol represents:



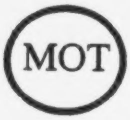
a. A common tie point
b. Connection to frame
c. A DC source
d. An AC source

38. The below symbol represents:



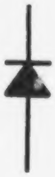
a. A common tie point
b. Connection to frame
c. A DC source
d. An AC source

39. The below symbol represents



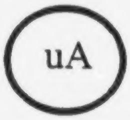
a. An AC source
b. A DC source
c. A meter
d. A motor

40. The below symbol represents



a. An AC source
b. A DC source
c. A diode
d. A motor

41. The below symbol represents



a. An AC source
b. A generator
c. A meter
d. A motor

Electrical/Electronic Symbols and Ladder Diagrams

42. On a properly drawn ladder diagram, the location of the _____ that the contacts of a relay may be found will be located next to the ________

a. rail , contacts
b. rung , contacts
c. rail , relay coil
d. rung , relay coil

43. On a properly drawn ladder diagram, when a line passes through a symbol, its __________ changes.

a. appearence
b. rung number
c. wire number
d. rail number

44. The first section of an electrical ladder diagram details the:

a. Relays
b. Primary power distribution
c. rungs
d. wiring

45. On some types of ladder diagrams, the location of the _____ that the contacts of a relay may be found will be located in a ________

a. rail , contacts
b. rung , relay table
c. rail , relay coil
d. rung , relay coil

46. If a technician desired to determine whether or not a piece of electronic equipment was performing correctly, the technician would refer to the:

a. layout drawing
b. symbol/value table
c. specification table
d. model number

47. A schematic diagram details how the components in a piece of electronic equipment are:

a. laid out on the printed Circuit board
b. connected together
c. valued
d. soldered

48. On a properly drawn ladder diagram, the _______ are number sequentially, while the __________ are wire numbers.

a. rails, rungs
b. rung, number
c. wires, rungs
d. rungs, rails

49. On drawing number 3 the value of fuse F1 is:

a. 1 Amp
b. 5 Amps
c. 10 Amps
d. 3 Amps

50. On drawing number 3 the overload for relay M1 connects between the relay _____ and ______.

a. contacts, wire 9
b. coil, wire 2
c. contacts, coil
d. contacts, ground

51. On drawing number 3 the overload for relay M1 is a:

a. m,agnetic overload
b. shunt trip
c. thermal
d. draw out

52. On drawing number 3 Push button 2 is:

a. normally closed
b. normally open
c. not pressed
d. depressed

53. On drawing number 3 the normally open A contacts of relay M2 lie between wire___ and wire ____.

a. 6, 7
b. 8, 9
c. 3, 9
d. 4, 5

54. On drawing number 3 the normally open B contacts of M1 lie between wires ____ and ____.

a. 6, 7
b. 8, 9
c. 3, 6
d. 4, 5

55. On drawing number 3 to test the normally closed contacts of relay K101 the meter must be placed on wires _____ and ______.

a. 6, 7
b. 8, 9
c. 3, 6
d. 4, 5

56. On drawing number 3 the normally closed A contacts of relay K3 may be found at rung:

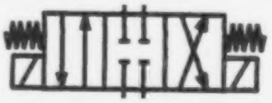
a. 12
b. 53
c. 2
d. 43

57. On drawing number 3 the rails are wires _____ and ____

a. 6, 7
b. 8, 9
c. 3, 6
d. 3, 2

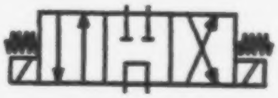
Fluid Power Symbols

58. The below symbol represents:



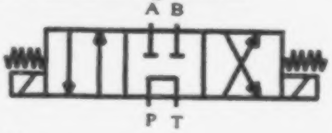
a. a 4 way bi-directional valve, closed center, solenoid operated, and spring centered.
b. a 2 way normally open valve, solenoid operated and spring biased.
c. a 4 way bi-directional valve, open center, solenoid operated, and spring centered.
d. a 2 way normally closed valve, solenoid operated and spring biased.

59. The below symbol represents:



a. a 4 way bi-directional valve, tandem center, solenoid operated, and spring centered.
b. a 2 way normally open valve, solenoid operated and spring biased.
c. a 4 way bi-directional valve, internally piloted, solenoid operated, and spring centered.
d. a 2 way normally closed valve, solenoid operated and spring biased.

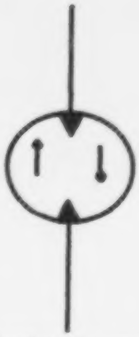
60. In the below symbol, when the valve is in its center position:



a. A and B are closed and P is connected to T
b. A, B, P, and T are connected to each other
c. A is connected to B and P and T are closed
d. A, B, P, and T are closed

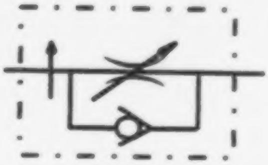
Manufacturing Technology 102 Final Exam

61. The below symbol represents:



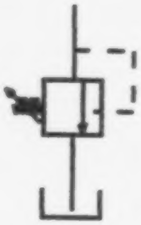
a. a pressure and temperature compensated hydraulic motor
b. a pressure compensated hydraulic pump
c. a single acting hydraulic cylinder
d. a pressure and temperature compensated hydraulic pump

62. The below symbol represents:



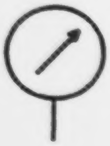
a. a pressure compensated flow control valve with integral check valve
b. a double acting hydraulic cylinder
c. a single acting hydraulic cylinder
d. a pressure and temperature compensated flow control valve

63. The below symbol represents:



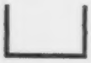
a. a pressure compensated flow control valve
b. a pressure relief valve
c. a single acting hydraulic cylinder
d. a pressure and temperature compensated flow control valve

64. The below symbol represents:

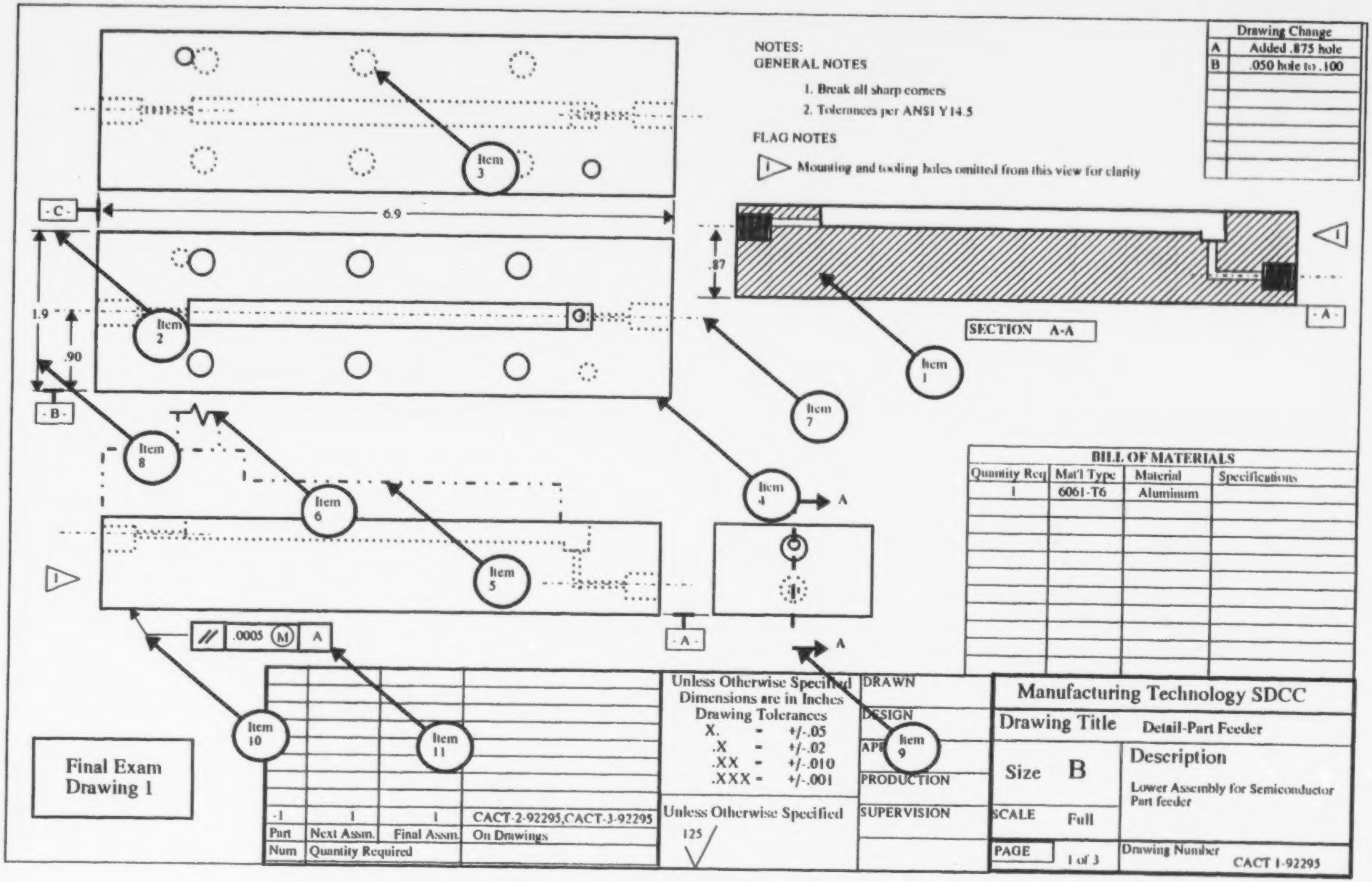


a. a pressure compensated flow control valve
b. a pressure relief valve
c. a single acting hydraulic cylinder
d. a pressure gauge

65. The below symbol represents:



a. a closed tank
b. a pressure relief valve
c. a tank open to atmosphere
d. a pressure gauge


Item 1
Item 2
Item 3
Item 4
Item 5
Item 6
Item 7
Item 8
Item 9
Item 10
Item 11
6.9
1.9
.90
.87
- C -
- B -
- A -
SECTION A-A
A
1
.0005 Ⓜ A

NOTES:
GENERAL NOTES

1. Break all sharp corners
2. Tolerances per ANSI Y14.5

FLAG NOTES

1 Mounting and tooling holes omitted from this view for clarity

Drawing Change	
A	Added .875 hole
B	.050 hole to .100

BILL OF MATERIALS			
Quantity Req	Mat'l Type	Material	Specifications
1	6061-T6	Aluminum	

Final Exam Drawing 1

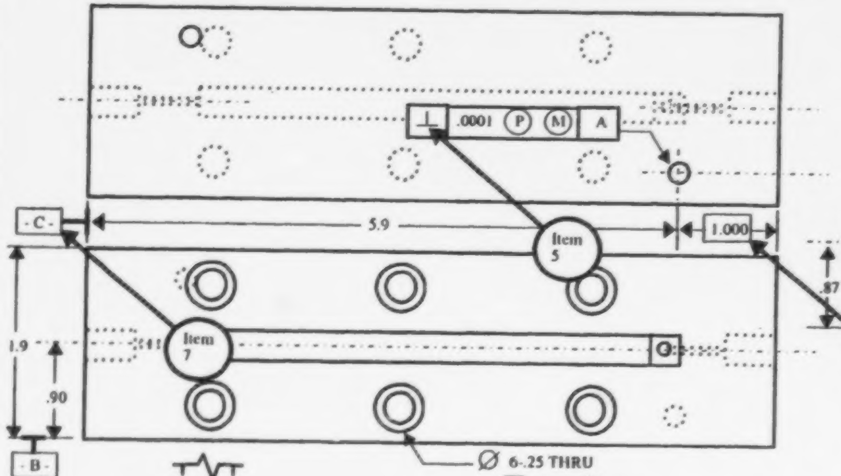
-1	1	1	CACT-2-92295,CACT-3-92295
Part	Next Assm.	Final Assm.	On Drawings
Num	Quantity Required		

Unless Otherwise Specified
Dimensions are in Inches
Drawing Tolerances
X. = +/-.05
.X = +/-.02
.XX = +/-.010
.XXX = +/-.001

Unless Otherwise Specified
125 √

DRAWN
DESIGN
APP
PRODUCTION
SUPERVISION

Manufacturing Technology SDCC
Drawing Title Detail-Part Feeder
Size B
SCALE Full
Description
Lower Assembly for Semiconductor Part feeder
PAGE 1 of 3
Drawing Number CACT 1-92295


- C -
5.9
1.000
.0001 Ⓟ Ⓜ A
Item 5
Item 7
1.9
.90
- B -
⌀ 6-.25 THRU

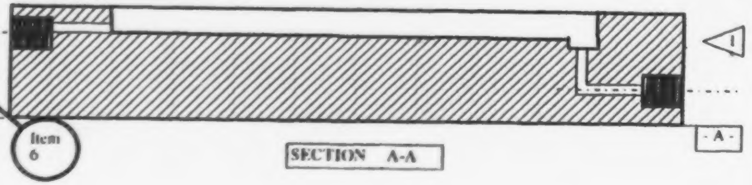
NOTES:
GENERAL NOTES

1. Break all sharp corners
2. Tolerances per ANSI Y14.5

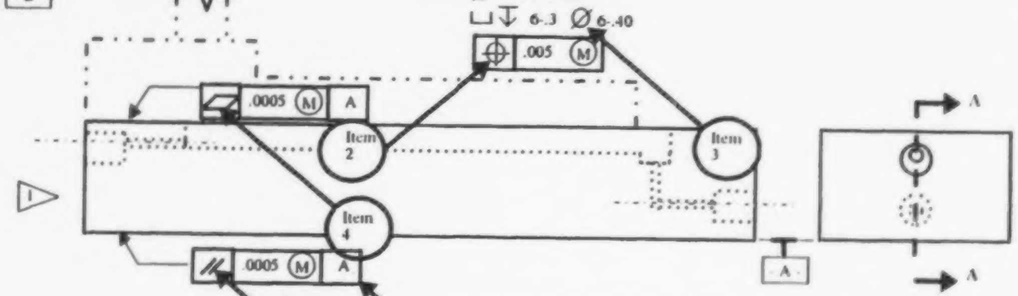
FLAG NOTES

1 ▷ Mounting and tooling holes omitted from this view for clarity

Drawing Change	
A	Added .875 hole
B	.050 hole to .100



SECTION A-A


⌴ ↧ 6-.3 ⌀ 6-.40
⌖ .005 Ⓜ
▱ .0005 Ⓜ A
Item 2
Item 3
Item 4
1
// .0005 Ⓜ A
- A -
A
A

BILL OF MATERIALS			
Quantity Req	Mat'l Type	Material	Specifications
1	6061-T6	Aluminum	

Item 1
Item 8

-1	1	1	CACT-2-92295,CACT-3-92295
Part	Next Assm.	Final Assm.	On Drawings
Num	Quantity Required		

Final Exam
Drawing 2

Unless Otherwise Specified
Dimensions are in Inches
Drawing Tolerances
X. = +/-.05
.X = +/-.02
.XX = +/-.010
.XXX = +/-.001

Unless Otherwise Specified
125 √

DRAWN	
DESIGN	
APPROVED	
PRODUCTION	
SUPERVISION	

Manufacturing Technology SDCC

Drawing Title Detail-Part Feeder

Size B

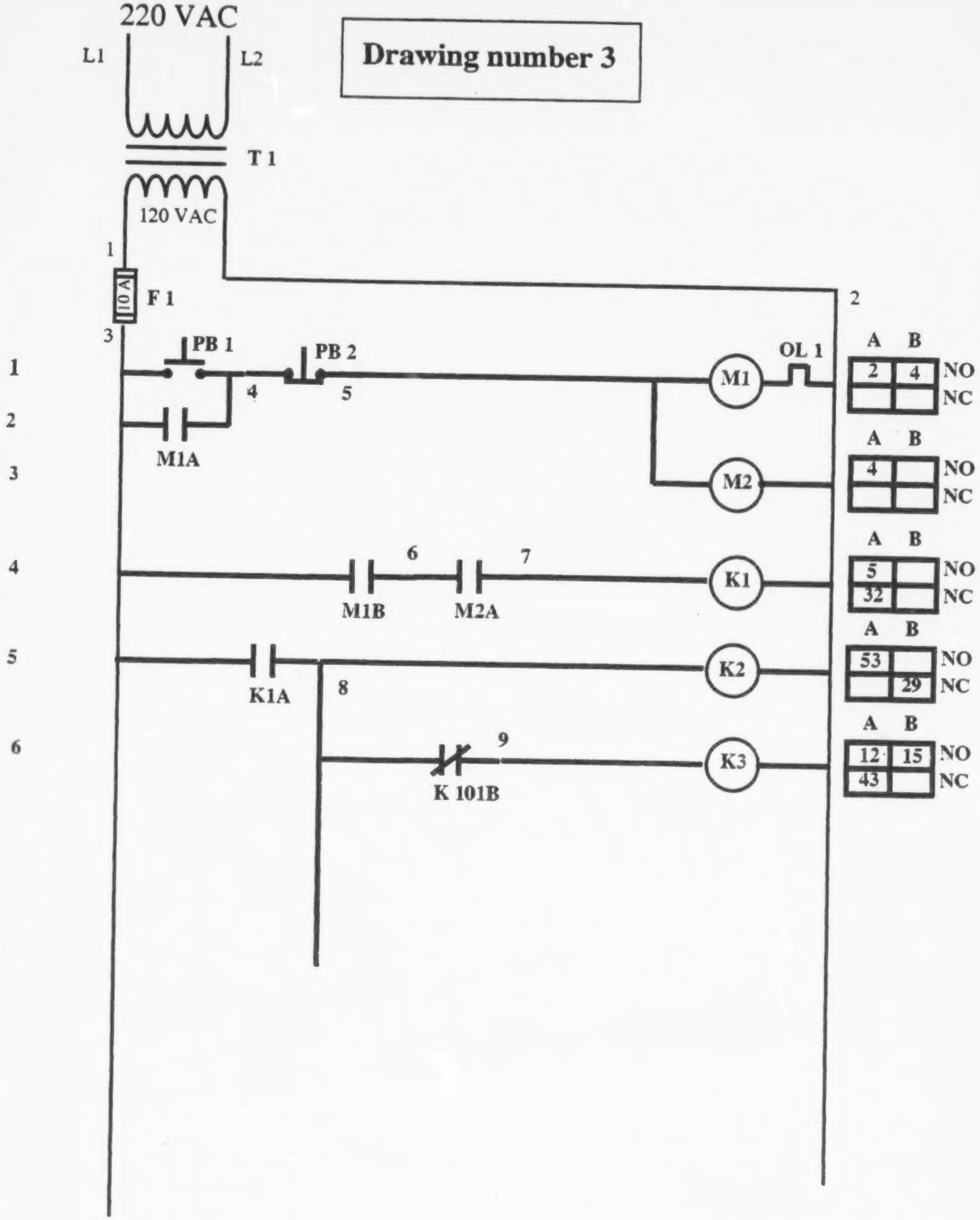
Description
Lower Assembly for Semiconductor Part feeder

SCALE Full

PAGE 1 of 3

Drawing Number CACT 1-92295

Drawing number 3


220 VAC
L1
L2
T 1
120 VAC
1
10 A
F 1
3
2
1
2
3
4
5
6
PB 1
PB 2
4
5
M1A
OL 1
M1
M2
6
7
M1B
M2A
K1
K1A
8
K2
9
K 101B
K3
A B
2 4 NO
NC
A B
4 NO
NC
A B
5 NO
32 NC
A B
53 NO
29 NC
A B
12 15 NO
43 NC

Manufacturing Technology 111 Final Exam

Convert the following decimal numbers into binary

1. 255 to binary

a. 10000000
b. 11111111
c. 11111110
d. 100000000

2. 1024 to binary

a. 11111111110
b. 1000000000
c. 10000000000
d. 100000000

3. 2753 to binary

a. 111010111
b. 100100101011
c. 111000111000
d. 101011000001

4. 32767 to binary

a. 1111111111111111
b. 111111111111111
c. 100000000000001
d. 1000000000000000

Convert the following binary numbers into decimal

5. 111111100 to decimal

a. 1024
b. 968
c. 254
d. 1020

6. 10000000000 to decimal

a. 2048
b. 512
c. 1024
d. 511

Manufacturing Technology 111 Final Exam

7. 10000011 to decimal

a. 64
b. 131
c. 65
d. 129

8. 1011001100 to decimal

a. 716
b. 1740
c. 598
d. 204

Convert the following binary numbers into octal

9. 11111111111 to octal

a. 177
b. 377
c. 877
d. 3777

10. 100111010 to octal

a. 571
b. 472
c. 872
d. 1162

11. 111000110000 to octal

a. 3820
b. 7060
c. 3420
d. 3510

12. 100000110111 to octal

a. 4067
b. 8037
c. 4037
d. 4057

DO NOT WRITE ON THE EXAM!

Manufacturing Technology 111 Final Exam

Convert the following octal numbers into binary

13. 7345 to binary

a. 111000111000
b. 1111100101
c. 111011100101
d. 11101100110

14. 70337 to binary

a. 11011000110111
b. 111000011011111
c. 100011100111000
d. 1111101111

15. 37777 to binary

a. 111111111111111
b. 100111111111111
c. 111000111011011
d. 11111111111111

16. 12345 to binary

a. 101011100101
b. 1010011100101
c. 1001000110110101
d. 100100011011010

Convert the following Hexadecimal numbers into binary

17. FFFF to binary

a. 1111111111111111
b. 1111111111110000
c. 1010101010101010
d. 11111111111111111

18. A0B0 to binary

a. 1101000010110000
b. 10101011
c. 101000101100
d. 1010000010110000

Manufacturing Technology 111 Final Exam

19. 23AF

a. 11110101111
b. 100000001111
c. 10001110101111
d. 1001110101111

20. E00F

a. 11110000
b. 111000000001111
c. 1111000000001111
d. 1110000000001111

Convert the following binary numbers into hexadecimal

21. 1111111 to hex

a. 1F
b. FF
c. 7F
d. 3F

22. 10100000 to hex

a. A0
b. B0
c. 50
d. C0

23. 1111000011111111 to hex

a. FFF
b. F0FF
c. E0FF
d. 1E0FF

24. 1110000010110111 to hex

a. E0B7
b. 7B7
c. B0B7
d. 7B70

Add the following binary numbers

25. 11101010 + 1101

a. 11111111
b. 11110111
c. 111101110
d. 100000001

26. 1000000000 + 111

a. 10000000111
b. 1000000100
c. 1100000010
d. 1000000111

27. 1000001 + 11111101

a. 10111111
b. 11111111
c. 100111101
d. 101111111

28. 1011001100 + 11110000

a. 1100111100
b. 10000000000
c. 10000111100
d. 11000011110

Subtract the following binary numbers

29. 11111111 - 11

a. 100000001
b. 11111100
c. 111111110
d. 101111110

30. 10011101 - 1001

a. 11110111
b. 11110000
b. 10010100
d. 11111110

31. 10100010000 - 100011

a. 10011101101
b. 110011101101
c. 110000010100
d. 10000010100

32. 100000110111 - 11100000

a. 11101010111
b. 10011101101
c. 10000000001
d. 11111010111

Convert the following decimal numbers into Binary Coded Decimal (BCD)

33. 1299 to BCD

a. 1000001010011001
b. 0001001010011001
c. 101010011001
d. 1001001010101001

34. 55 to BCD

a. 101101
b. 10101010
c. 01010101
d. 10011001

35. 99221 to BCD

a. 10011001001000100001
b. 1001100110101
c. 10010110010010
d. 01011001002000020001

36. 12345 to BCD

a. 00010010001101000101
b. 100111100101
c. 011011100101

Manufacturing Technology 111 Final Exam

Convert the following BCD numbers into decimal.

37. 0011100100100100 to decimal

a. 13904
b. 012345
b. 3924

38. 10010101011100011000 to decimal

a. 90501
b. 95718
c. 1002507

39. 0001001100000000 to decimal

a. 1300
b. 130
c. 11100

40. 1000000000000000 to decimal

a. 80
b. 8000
c. 100000

Identify the following

41. Law of association

a. $A = \bar{\bar{A}} = A$

b. $A+(B*C)=(A+B)*(A+C)$

c. $\overline{A*B}=\bar{A}+\bar{B}$

d. $A*(B*C)=D$

42. Law of distribution

a. $A = \bar{\bar{A}} = A$

b. $A+(B*C)=(A+B)*(A+C)$

c. $\overline{A*B}=\bar{A}+\bar{B}$

d. $A*(B*C)=D$

43. Law of double complementation

a. $A = \bar{\bar{A}} = A$

b. $A+(B*C)=(A+B)*(A+C)$

c. $\overline{A*B}=\bar{A}+\bar{B}$

d. $A*(B*C)=D$

44. DeMorgan's Theorem

a. $A = \bar{\bar{A}} = A$

b. $A+(B*C)=(A+B)*(A+C)$

c. $\overline{A*B}=\bar{A}+\bar{B}$

d. $A*(B*C)=D$

45. Word problem Using the laws of combination and DeMorgan's theorem, reduce the following Boolean expression to its simplest form.

$$\bar{A}*\bar{B}*\bar{C}+C+\bar{A}*\bar{B}*\bar{C}+B+\bar{A}*\bar{C}*\bar{B}+A=D$$

a. $A = D$
b. $D=1$
c. $D=0$
d. $A*B*C=0$

46. Multiple choice The below truth table is the truth table of the:

a	b = c
1	0 = 1
0	1 = 1
1	1 = 0
0	0 = 1

a. OR function
b. AND function
c. NAND function
d. NOR function
e. XOR function

47. Multiple choice The below truth table is the truth table of the:

a	b = c
1	0 = 0
0	1 = 0
1	1 = 0
0	0 = 1

a. OR function
b. AND function
c. NAND function
d. NOR function
e. XOR function

48. Multiple choice The below truth table is the truth table of the:

a b = c

1 0 = 1
0 1 = 1
1 1 = 1
0 0 = 0

a. OR function
b. AND function
c. NAND function
d. NOR function
e. XOR function

49. Multiple choice The below truth table is the truth table of the:

a b = c

1 0 = 1
0 1 = 1
1 1 = 0
0 0 = 0

a. OR function
b. AND function
c. NAND function
d. NOR function
e. XOR function

50. Multiple choice The below truth table is the truth table of the:

a b = c

1 0 = 0
0 1 = 0
1 1 = 1
0 0 = 0

a. OR function
b. AND function
c. NAND function
d. NOR function
e. XOR function

51. Reduce the following Boolean expression to its simplest terms

$$A * B + A * C = D$$

a. $A + B + C = D$
b. $A + B * C = D$
c. $A * (B + C) = D$

52. Multiple choice A microprocessor executes ________

a. data
b. ASCII
c. instructions

53. Multiple choice A microprocessor performs almost all math by _____

a. adding
b. subtracting
c. dividing
d. multiplying

54. Multiple choice In the microprocessor, the program counter is used to:

a. count the program
b. address memory
c. count addresses
d. count cycles

55. Multiple choice ROM stands for:

a. Random Access Memory
b. PIA
c. Read Only Memory
d. Random Only Memory

56. Multiple choice RAM stands for:

a. Random Access Memory
b. PIA
c. Read Only Memory
d. Random Only Memory

57 Multiple choice PROM stands for:

a. Program counter
b. Random Access Memory
c. Programmable Read Only Memory

58. Multiple choice EPROM stands for:

a. Emergency Programmable Random Access Memory
b. Electrically Programmable Read Only Memory
c. Erasable Programmable Read Only Memory

59. Multiple choice If an overflow occurs on the stack the result will be:

a. nothing happens
b. an error message
c. the computer will most likely lock up

60. Multiple choice If the microprocessor fetches a byte of data and executes it as an instruction, the most likely result will be:

a. nothing happens
b. an error message
c. computer lock up

61. Multiple choice What pin on the microprocessor determines whether or not the microprocessor is reading from memory?

a. the address pins
b. the data pins
c. the clock
d. the read, not write pin.

62. Multiple choice If the microprocessor is interrupted too often by some device, the most likely result will be:

a. a stack overflow
b. the status register will set the ignore interrupt flag
c. nothing happens.

63. Multiple choice During an interrupt, the microprocessor runs a______ to service the _____ that caused the interrupt.

a. counter, memory
b. program, device
c. register, the accumulator

64. True/false During the check-out of a microprocessor controlled device, the operation of the support chips can be ignored.

a. true
b. false

65. Multiple choice The address pins on a microprocessor are ___________ while the data pins are ___________

a. unidirectional, bi-directional
b. bi-directional, unidirectional

66. Multiple choice The pins on a microprocessor that are used to signal the chip that an external device requires its attention are:

a. the clock pins
b. the read/not write pin
c. the interrupt pins

67. Multiple choice A group of instructions and data in the memory of a microprocessor system that is used to direct the operations of a microprocessor is called a:

a. PIA
b. video memory
c. interrupt
d. program

68. Multiple choice: Which of the below is not a programming language

a. assembly
b. basic
c. hexadecimal
d. C

69. Multiple choice: The binary instructions that operate the microprocessor are also known as:

a. hexadecimal
b. octal
c. BCD
d. machine language

70. Multiple choice: Structured programming requires the following process:

a. inputs, processing, outputs
b. inputs, outputs
c. binary, hexadecimal, binary
d. hexadecimal, binary, hexadecimal

71. Multiple choice: The process for the program is declared in the:

a. variables
b. header
c. body of the program
d. macros

72. Multiple choice: A string variable contains:

a. decimal numbers expressed in binary
b. whole numbers expressed in binary
c. ASCII characters expressed in binary
d. BCD

73. Multiple choice: An integer variable contains:

a. decimal numbers expressed in binary
b. whole numbers expressed in binary
c. ASCII characters expressed in binary
d. BCD

74. Multiple choice: A real variable contains:

a. decimal numbers expressed in binary
b. whole numbers expressed in binary
c. ASCII characters expressed in binary
d. BCD

73. Multiple choice: A double precision variable contains:

a. decimal numbers expressed in binary
b. whole numbers expressed in binary
c. ASCII characters expressed in binary
d. BCD

74. Multiple choice: At the end of the following program fragment, variable A$ contains:

```
100 FOR X = 1 TO 10
110 A$=A$+STR$(X)
120 NEXT X
```

a. the real numbers 1,2,3,4,5,6,7,8,9,10
b. the integer numbers 1,2,3,4,5,6,7,8,9,10
c. the ASCII characters 1,2,3,4,5,6,7,8,9,10
d. none of the above

75. Multiple choice: At the end of the following program fragment variable A contains:

```
100 FOR X = 1 TO 10
110 A=(X)
120 NEXT X
```

a. the real numbers 1,2,3,4,5,6,7,8,9,10
b. the integer numbers 1,2,3,4,5,6,7,8,9,10
c. the ASCII characters 1,2,3,4,5,6,7,8,9,10
d. none of the above

76. Multiple choice: At the end of the following program fragment variable A% contains:

```
100 FOR X = 1 TO 10.1
110 A%=A%+X
120 NEXT X
```

a. 10.1
b. 10
c. the integer numbers 1,2,3,4,5,6,7,8,9,10,10.1
d. 65

77. Multiple choice: At the end of the following program fragment variable A contains:

```
100 FOR X = 1 TO 10.5
110 A=(X)
120 NEXT X
```

a. 10
b. 10.5
c. the real numbers 1,2,3,4,5,6,7,8,9,10,10.5
d. none of the above

78. Multiple choice: At the end of the following program fragment variable A$ contains:

```
100 FOR X = 1 TO 10.5
110 A$=STR$(X)
120 NEXT X
```

a. 10
b. 10.5
c. the ASCII characters 1,2,3,4,5,6,7,8,9,10.5
d. the ASCII characters 1,2,3,4,5,6,7,8,9,10,10.5

79. True/false: There is only one microprocessor in a desk top computer.

a. true
b. false

80. True/false: There is only one microprocessor in a robot or CNC control computer.

a. true
b. false

81. Multiple choice: Order the following programming languages from lower level (closest to machine language) to highest level (closest to macro).

1. data base language
2. assembly language
3. C
4. basic

a. 1,2,3,4
b. 2,3,4,1
c. 3,4,1,2
d. 4,3,2,1

82. Multiple choice: In DOS, on an IBM type computer, to access the list of files on a disk, the command is:

a. FILES
b. LIST
c. DOS
d. DIR

83. Multiple choice: In BASIC, on an IBM type computer, to access the list of files on a disk, the command is:

a. FILES
b. LIST
c. DOS
d. DIR

84. Multiple choice: In DOS, on an IBM type computer, to change directories, the command is:

a. FILES
b. CD
c. DOS
d. DIR

85. Multiple choice: In DOS, on an IBM type computer, to start an application program, the command is:

a. the name of the program
b. PS
c. DOS
d. CD

86. Multiple choice: The command "TYPE" is an ______ DOS command whereas the command "FORMAT " is an _____ DOS command.

a. external, internal
b. common, external
c. internal, external
d. ordinary, internal

87. Multiple choice: The two files that customize a DOS (IBM) type computer to the user's needs are:

a. COMMAND.COM and IBM DOS
b. CONFIG.SYS and COMMAND.COM
c. AUTOEXEC.BAT and DOS
d. AUTOEXEC.BAT and CONFIG.SYS

88. Multiple choice: Programs that allow the computer to operate add on devices such as modems, sound cards, video display cards, and others are called:

a. AUTOEXEC programs
b. CONFIGURE programs
c. device drivers

89. Multiple choice: Programs that allow the computer to operate add on devices such as modems, sound cards, video display cards, and others are loaded in:

a. AUTOEXEC.BAT
b. CONFIG.SYS
c. MSDOS
d. a and b above

90. Multiple choice: Factory hardened computers are computers that :

a. have been shielded against Apples
b. have been shielded against EMI, dirt, and oily contaminants
c. have been shielded against untrained operators

91. True/false A robot program is the same as a BASIC program

a. true
b. false

92. Multiple choice: All programming languages are alike in the sense that they all emulate the functions of the:

a. microprocessor
b. memory
c. input devices
d. output devices

The next 8 questions refer to the following program fragment.

```
300 '***********PROGRAM SAVE**************
310 OPEN "COM2:9600,E,7,2" AS #1
320 INPUT "FILE NAME (*.PRG)=";F$
330 OPEN "A:"+F$ FOR OUTPUT AS #2
340 INPUT "START LINE=";S
350 INPUT "END LINE=";E
360 FOR L=S TO E
370   PRINT #1, "LR"+STR$(L)
380   LINE INPUT #1,A$
390   IF A$="" THEN 410
400   PRINT #2,L;:PRINT #2,A$:PRINT L;:PRINT A$
410 NEXT L
420 CLOSE
430 GOTO 170
```

93. Multiple choice: When the user of this program enters "MYFILE" at line 320, A$ will contain:

a. ""
b. "MYFILE"
c. "A:"
d. "OUTPUT"

94. Multiple choice: If the user of this program enters 10 on line 340 and 50 on line 350, then line 370 will be executed:

a. 50 times
b. 40 times
c. 44 times
d. 41 times

95. Multiple choice: Line 330 opens the:

a. communications port for output
b. the hard disk drive for output
c. the floppy disk drive for output
d. communications port for input

96. Multiple choice: The program will not execute line 420 until:

a. E=10
b. L=E
c. L=10
d. E=S

97. Multiple choice: To change this program to work on serial port number 1, line number _____ needs to be changed to read ____________:

a. 420, CLOSE COM1
b. 330, OPEN "COM1" FOR OUTPUT AS #1
c. 370, PRINT #2, "LR"+STR$(L)
d. 310, OPEN "COM1:9600,E,7,2" AS #1

98. Multiple choice: To allow the program to communicate on serial port number 2 with a modem or terminal that works at 4800 baud, no parity, 8 bits, 1 stop bit, line ____ needs to be changed to read _______.

a. 420, OPEN "COM1:4800,E,7,2" FOR OUTPUT AS #1
b. 310, OPEN "COM2:4800,N,8,1" AS #1
c. 370, OPEN "COM1:4800,N,8,1" AS #1
d. 310, OPEN "COM2:4800,E,8,1" AS #1

99. Multiple choice: If line 410 was REMarked out or otherwise eliminated from the program, the computer would:

a. halt the program with a "FOR WITHOUT NEXT ERROR IN LINE 420"
b. fail to close the COM ports
c. nothing would happen
d. halt the program with a "PORT NOT OPEN ERROR"

100. Multiple choice: Programming is:

a. Fun
b. you had better answer "a"

Manufacturing Technology 106 Final Exam

1. How much force in newtons is needed to accelerate a 300 kg automobile at a rate of 10 m/sec^2?

a. 3000 N
b. 3.0 x 10^4 N
c. 3.0 x 10^3 N
d. 30,000 lbs

2. What is the weight in lbs of a 2000 kg mass?

a. 4400 lbs
b. 500 N
c. 9800 N
d. 2200 lb

3. What is the weight in newtons of a 100 kg mass?

a. 454.5 N
b. 32,000 N
c. 980 N
d. 1000 N

4. A 10 kg mass is moving at a velocity of 10 m/sec. We desire to bring the mass to a complete stop (relative to us) in 2 seconds. This will require the application of a force of:

a. 10 joules
b. 50 watts
c. 50 Newtons
d. 100 Newtons

5. A 5 kg mass weighs:

a. 49 N
b. 4.4 lbs
c. 8.8 joules
d. 9.8 N*m

6. How much time will it take to bring a 500 kg machine slide to a complete halt from a velocity of 2 m/sec if a force of 1000 newtons is applied to halt the slide?

a. 1 sec
b. .148 sec
c. 2 sec
d. 5 sec

7. A 5 kg mass weighs:

a. 96 pounds
b. 29.4 Newtons
c. 96 Newtons
d. 11 pounds

8. How much force must be applied to a machine to stop it if it has a momentum of 2 kg*m/sec and it is desired to stop it in .5 sec?

a. 1 N
b. 2 N
c. 3 N
d. 4 N

9. The coefficient of friction of lubricated steel sliding on teflon is .04. If the sliding force of a lubricated machine slide composed of these materials is 13 lbs. What is the weight of the machine slide?

a. 100 lbs
b. 325 lbs
c. 50 lbs
d. 1250 lbs

10. Two of the same model automobiles of equal weights are equipped with tires of the same material. Car A has wide tires, and car B has narrow tires. If car A has a sliding force of 500 lbs, the sliding force of car B will be:

a. 200 lbs
b. 1000 lbs
c. 500 lbs
d. none of the above

11. How many feet are there in 100 meters?

a. 100 ft
b. 328 ft
c. 20 ft
d. 65.6 ft

12. How many Newtons are in a 50 lb weight?

a. 500 N
b. 2224 N
c. 112 N
d. 222.5 N

13. If I move a 100 kg mass 5 meters at a rate of 2 m/sec^2. How much work have I accomplished?

a. 500 Joules
b. 5000 Joules
c. 5000 ft*lbs
d. 1000 Joules

14. The formula for calculating work is

a. w = m*v
b. w = m*a
c. w = F*d
d. w = m*v

15. One of the acceleration constants used in calculating force is:

a. 32 ft*sec
b. 9.8 m*sec
c. 32 m/sec^2
d. 9.8 m/sec^2

16. 40 N*m is equivalent to:

a. 30 pounds
b. 30 Newtons
c. 40 J
d. 40 ft*lbs

17. A hoist lifts a 550 pound weight one foot in 1 sec. How many horsepower is required to accomplish this?

a. 1 horsepower
b. .5 horsepower
c. 10 horsepower
d. 2 horsepower

18. A single phase 440 volt electrical motor consumes 10 amps. If power in watts, in an electrical circuit, is equal to voltage multiplied by current, how many horsepower is the motor consuming?

a. 2.95 horsepower
b. 4 horsepower
c. 5.9 horsepower
d. 1 horsepower

19. A single phase 220 volt electrical motor consumes 15 amps of current when lifting a weight on a hoist a distance of 1 meter in 4 sec. How much in Newtons does the weight weigh? (assume no losses in the system)

a. 1650 N
b. 13200 N
[✓ c. 6600 N]
d. 3300 N

20. A scaler quantity:

a. has a value but no direction
b. has a value and a direction

21. A vector quantity:

a. has a value but no direction
b. has a value and a direction

22. The resultant vectored force of two equal forces acting at right angles (90 degrees) to each other has a vector angle of:

a. 30 degrees
b. 45 degrees
c. 60 degrees
d. 90 degrees

23. The geometric diagram of two vectored forces acting at an angle to each other and their resultant is called:

a. a scaler
b. a vector
c. a parallelogram of forces
d. none of the above

24. Two vectored forces acting in exact opposition to each other measure 20 newtons in direction A and 40 newtons in direction B. The resultant of this system of forces is:

a. 40 Newtons in direction A
b. 40 Newtons in direction B
c. 20 Newtons in direction A
d. 20 Newtons in direction B

25. A system of two parallel equal forces acting in exact opposition to each other at a distance apart is called:

a. a vector
b. a scaler
c. a parallelogram of forces
d. a couple

26 . In an angular motion system, a force applied at a distance from a pivot point is known as a:

a. joule
b. power
c. torque
d. momentum

27. When a mass translates in a circle around a pivot point, the vectored force trying to trying to hold the mass to the pivot point is known as ____________ force

a. centripetal force
b. centrifugal force

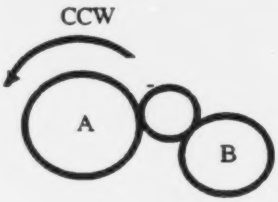
28. The force tending to make the mass fly away from the pivot point is known as:

a. centripetal force
b. centrifugal force

29. Uniform motion around a circle at a distance from a pivot point is always called angular acceleration because the _________ changes constantly:

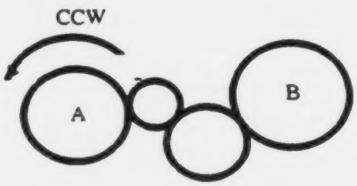
a. force
b. power
c. vectored force
d. mass

30. In gear train shown below, the direction of motion of gear B will be:



a. clockwise
b. counterclockwise

31. In gear train shown below, the direction of motion of gear B will be:



a. clockwise
b. counterclockwise

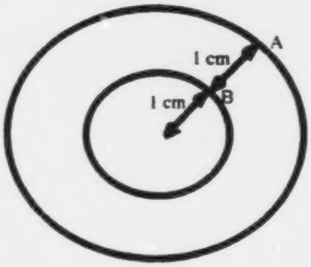
32. The mechanical advantage of an inclined plane that has a ramp of 12 ft and a rise of 4 ft is:

a. 1/3
b. 12
c. 4
d. 3

33. An inclined plane that is wrapped around a round shaft is known as a:

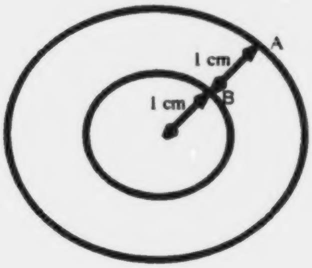
a. rod
b. screw
c. shaft
d. ramp

34. In the gear assembly shown below, the force at point B is 200 newtons, what is the torque at point A?



a. 200 Newton * meters
b. 40 Newton * meters
c. 2 Newton * meters
d. 100 Newton * meters

35. In the gear assembly shown below, the force at point B is 200 Newtons. What is the force at point A?



a. 100 N
b. 200 N
c. 400 N
d. 50 N

36. Mass Density is calculated by dividing a substances _______ by its ___________

a. volume, force
b. volume, mass
c. mass, volume
d. mass, specific gravity

37. The density of chemically pure water is:

a. 1200 Kg/lb
b. 1000 N/gal
c. 900 Kg/litre
d. 1000 Kg/cubic meter

38. It is desired to test the charge of a battery. A hydrometer is not available (a hydrometer tests specific gravity). A specific gravity of 1.4 represents a fully charged battery, and the battery contains 2 liters of liquid. What is the specific gravity of the liquid in the battery if its weight is 21 Newtons. (The liquid is water and acid.)

a. 1.400
b. 1.200
c. 1.000
d. 1.071

39. If the mass density of kerosene is 720 Kg/cubic metre, what is the approximate weight in lbs of fuel that a jet airplane has to lift of a volume of kerosene of 5000 gal.?

a. 6200 lbs
b. 5000 lbs
c. 11002 lbs
d. 1120 lbs

40. The pressure exerted upon a surface can be calculated by the following formula:

a. Pressure = Force*Area
b. Pressure = Force*Density
c. Pressure = Force*Weight
d. Pressure = Force / Area

41. Pounds per square inch (PSI) is an example of a _______ pressure scale.

a. force
b. linear
c. dimensional
d. absolute

42. Kilopascals is an example of a ______ pressure scale.

a. force
b. linear
[✓ c. gauge]
d. absolute

43. 0 PSIA is ____ PSIG.

a. -14.7
b. 30.0
c. +14.7
[✓ d. 0.0]

44. The unit of force scale measurement of pressure for the English Engineering system is the ________

a. newton
b. pascal
c. psi
d. webber

45. The pressure of the atmosphere is:

a. -101 Kpa
b. 30 in Hg
c. 101 pascals
d. -14.7 PSIA

46. 0 PSI vacuum is ______ PSIG

a. -14.7 PSIG
b. -5 PSIG
c. 0 PSIG
d. -9.7 PSIG

47. What is the compression ratio of a mechanical vacuum pump that is removing air from a vessel at an absolute pressure of 1 torr, if it is pumping the gas to 1 atmosphere of pressure?

a. 760 to 1
b. 1000 to 1
c. 760,000 to 1
d. 76,000 to 1

48. What is the pressure in PSIG of a pressure of 100 bar?

a. 2205 PSIG
b. 0 PSIG
c. 1470 PSIG
d. 15,000 PSIG

49. What is the force exerted upon a vessel that has a surface area of 10 square feet if the vessel is pumped down to 380 torr?

a. 100 pounds
b. 10584 pounds
c. 30,000 pounds
d. 25,225 pounds

50. What is 50 inches of water in PSIG?

a. -12.9 PSIG
b. 0 PSIG
c. 12.9 PSIG
d. 14.7 PSIG

51. Convert -5 degrees Celsius to Fahrenheit

a. 23 °F
b. 69.8°F
c. -10 °F
d. 200 ° F

52. Convert -4 degrees Fahrenheit to Celsius

a. 43.3 °C
b. -20 ° C
c. 100 ° C
d. 25 o C

53. SDG&E is charging $.12 per kilowatt hour for electricity. Assuming that the water heater in your house is electric, and you want the water heated to 140 degrees Fahrenheit, how much will it cost to heat the water for a 50 gallon water tank if the water in the tank is at 40 degrees Fahrenheit? (assume no losses)

a. $5.00
b. $.60
c. $1.20
d. $1.47

54. How many kilowatt hours are needed to raise a quantity of steel weighing 50 lbs from a temperature of 600 degrees Fahrenheit to 1500 degrees Fahrenheit? (Assume the specific heat is of steel is .11.)

a. 2.3 kWh
b. 1.02 kWh
c. 50 kWh
d. 1.45 kWh

55. Assume the relative humidity is 80%. How many grams of water will be removed from a vacuum furnace when the air is fully removed from the chamber, if the chamber is a cylinder 2 meters tall and 1 meter in diameter, and the ambient temperature is 32 degrees C ? (assume that air can hold 33.45 grams of water per m^3 at saturation at 32 degrees C)

a. 42 gm
b. 10.16 gm
c. 20.16 gm
d. 15.16 gm

56. It is desired to heat treat a quantity of steel in an oven. The weight of the steel is 2000 Newtons. What would the volume of the steel be? (Assume steel has a mass density of 7830 Kg/cubic meter.)

a. 52 litres
b. 34 litres
c. 12 litres
d. 26 litres

57. It is desired to set a machine in place on the second floor of a building. The machine weighs 4 tons. The machine is supported on four legs. Assuming that the weight of the machine is evenly distributed on each of the legs, what is the pressure applied to the floor, if each leg has a surface area of 5 square inches? (1 ton = 2000 lbs)

a. 800 lbs
b. 2000 lbs
c. 1600 lbs
d. 400 lbs

58. In the previous problem, the engineer finds that the bursting strength of the floor is 100 lbs/square inch. If the engineer wanted to limit the pressure at each leg to 1/2 the bursting strength of the floor, what size of a metal plate in square inches would be needed under each leg?

a. 100 in^2
b. 80 in^2
c. 16 in^2
d. 40 in^2

59. If the absolute pressure in a volume is 4.7 PSIA, what is the pressure in the BAR scale?

a. -.68 bar
b. -.32 bar
c. 1.0 bar
d. .32 bar

60. If the absolute pressure in a volume is 4.7 PSIA, what is the pressure in the TORR scale?

a. 760 millitorr
b. 243 torr
c. -300 torr
d. 517 torr

61. How much force is applied to a bolted cover of a chamber if the cover is 2 feet in diameter and the chamber is pressurized to 1200 lbs/square inch?

a. 2000 lbs
b. 904.8 k lbs
c. 4000 lbs
d. 542867 lbs

62. On the periodic table, the group VIIIA elements are also known as:

a. the inner transition elements
b. the metalloids
c. the noble gases
d. alkali metals

63. What is the atomic number of silicon?

a. 28.09
b. 21
c. 14
d. IIIA

64. The majority of elements in the periodic table are:

a. Gasses
b. metalloids
c. semiconductors
d. metals

65. The atomic weight of potassium is:

a. IA
b. 6.8 grams/mole
c. 39.10
d. 19

66. One mole of water (H_2O) has a mass of:

a. 18.016 grams
b. 18.016 liters
c. 34 grams
d. 18 kg

67. Sodium has _____ electron in its outer shell

a. 1
b. 2
c. 3
d. 4

68. In the periodic table, the relative size of an atom decreases from _____ to ______.

a. top to bottom
b. right to left
c. bottom to top
d. left to right

69. Both batteries and electroplating are examples of :

a. acids
b. bases
c. electrochemistry
d. molar masses

70. A quantity of distilled water has a high:

a. resistance
b. quantity of hydroxyls
c. quantity of hydrogen cations
d. valence

71. In water, the alkaline metals such as potassium and sodium produce_____ by absorbing_____ and releasing_____.

a. acids, hydroxyls, hydrogen ions
b. bases, hydroxyls, hydrogen ions
c. acids, hydrogen ions, hydroxyls
d. bases, hydrogen ions, hydroxyls

72. the relative abundance of hydrogen ions and hydroxyls in water solutions is known as:

a. valence
b. pH
c. electrochemistry
d. electrolysis

73. The process of softening metals is known as:

a. melting
b. quenching
c. annealing
d. cutting

74. The process of quenching metals makes them:

a. harder
b. softer

75. The primary modes of conveying heat are:

a. convection, radiation
b. convection, radiation, conduction
c. radiation, convection
d. radiation, conduction

76. The modes that can convey heat in an atmospheric furnace are:

a. convection, conduction
b. radiation, convection
c. radiation, conduction
d. convection, conduction, radiation

77. Radiation of heat is accomplished by:

a. hot air
b. vibration
c. infrared waves
d. conduction

78. An air conditioner has a motor that draws 15 amps when the air conditioner is operating. The motor operates at 120 volts AC. The air conditioner must cool a room from 88° F to 70° F. Assume that the motor operates the entire time that the room is being cooled, and there are no losses. What is the efficiency of the air conditioner if the room is 2.5 meters high x 3 meters wide x 4 meters long, the density of air at sea level is 1.2 kg/m^3, the specific heat of air is .24 kcal/kg*C°, and the time it takes to cool the room is 15 min ?

a. 22.3 %
b. 2.1 %
c. 2 %
d. 30 %

79. The concept of inertia states that a body in a state of uniform motion tends to resist a change in its motion.

a. true
b. false

80. A change in inertia that results in motion relative to an observer, results in imparting _____ to the object.

a. force
b. work
c. momentum
d. power

81. A mass/vol solution of 3 % that contains a liquid volume equivalent to 1 mole of pure H_2O, and a gram mass quantity of salt (NaCl), is to be augmented by a quantity of salt that will bring the salt in the solution to .1 mole of salt. How many grams of salt needs to be added to the solution?

a. .579 gram
b. 18.016 grams
c. 5.7898 grams
d. 57.898 grams

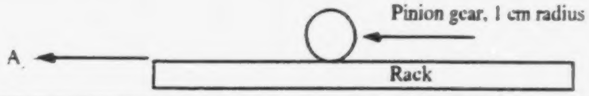
82. A tank of ethylene glycol (antifreeze) solution is tested to determine its concentration. The technician determines that the tank concentration is a 5 % solution, by volume, of ethylene glycol and water. The tank measures 35 feet long by 24 feet wide by 15 feet deep. The depth of the liquid is 3 feet from the top of the tank. Approximately How many 55 gallon drums of 100% ethylene glycol must be added to the tank to bring the concentration of antifreeze up to 10%. If the tank can only be filled to a depth of 13 feet, will the liquid added overfill the tank?

a. 76 , yes
b. 145, yes
c. 76, no
d. 145, no

83. An example of a surfactant is:

a. oil
b. water
c. soap
d. none of the above

84. In the below diagram, if the pinion gear has a torque of 1 N*M, and it moves clockwise, what is the force at point A?



a. 1 N
b. .5 N
c. 10 N
d. 100 N

85. When acetic acid and sodium bicarbonate are mixed, the reaction releases :

a. oxygen
b. hydrogen
c. carbon dioxide
d. chlorine

86. Acetic acid and bleach are mixed, the reaction releases:

a. oxygen
b. hydrogen
c. carbon dioxide
d. chlorine

87. Acetic acid or sodium bicarbonate are organic acids or bases because they contain:

a. oxygen
b. hydrogen
c. carbon
d. chlorine

88. True/false Water that contains acid is a stronger conductor than water that contains a base

[✓ a. true]
b. false

89. True/false Most elements do not exist as molecules containing single atoms

a. true
[✓ b. false]

90. True/false The noble gases always exist in nature as molecules containing two atoms.

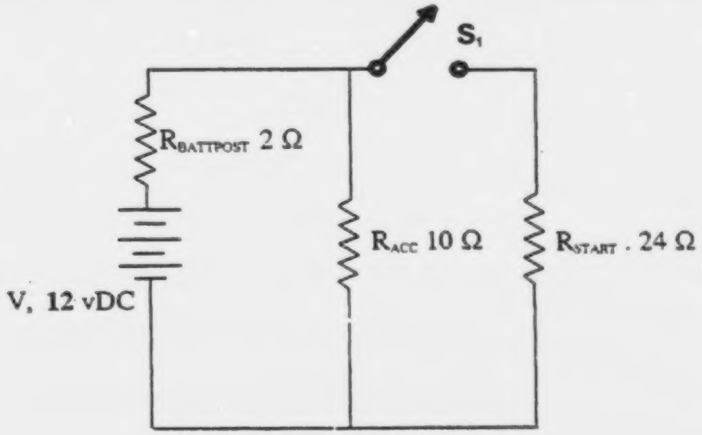
a. true
b. false

Manufacturing Technology 200 Final Exam

1. A technician desires to operate a complex circuit whose total load resistance is 2.0 ohms. The circuitry will operate reliably between 20 to 24 volts DC. He chooses a 24 volt DC source, and then tests its source resistance. Under no-load conditions, the source reads 24.5 VDC. With a 10 ohm load, the source drops to 24.0 VDC. What is the source resistance? Will the power supply operate the circuit?

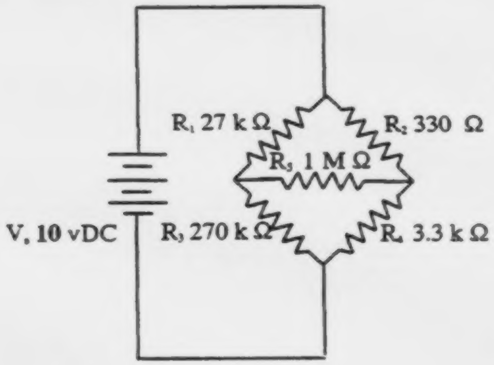
a. 1.0 ohms, no
b. .208 ohms, yes
c. 1.0 ohms, yes
d. .208 ohms, no

2. In the below circuit, Vs is 12 VDC, $R_{BATTPOST}$ is 2 ohms, R_{ACC} is 10 ohms R_{START} is .24 ohms. What will be the value of the voltage dropped across Racc when switch S1 is closed?



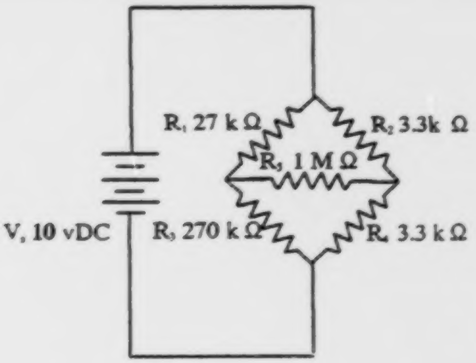
a. 10.86 VDC
b. 1.26 VDC
c. 4.56 VDC
d. 8.63 VDC

3. The below circuit is an example of:



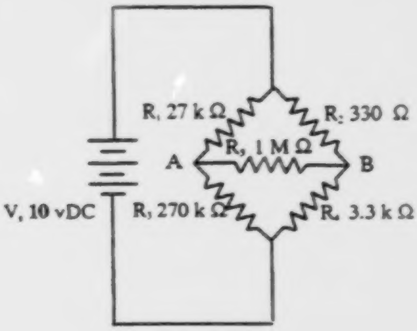
a. an unbalanced bridge circuit
b. a balanced bridge circuit

4. The below circuit is an example of:


R_1 27 kΩ
R_2 3.3k Ω
R_5 1 MΩ
V, 10 vDC
R_3 270 kΩ
R_4 3.3 kΩ

a. an unbalanced bridge circuit
b. a balanced circuit
c. a series circuit
d. a parallel circuit

5. In the below circuit, how much current would flow from point A to point B if R5 were shorted?


R_1 27 kΩ
R_2 330 Ω
R_5 1 MΩ
A
B
V, 10 vDC
R_3 270 kΩ
R_4 3.3 kΩ

a. 4 ma
b. 10 ma
c. infinite current
d. none

6. The current flowing through a 22 k ohm resistor is 4 ma. What is the voltage dropped across the resistor? (DC current)

a. 8.8 volts DC
b. 5.5 volts DC
c. 88 volts DC
d. 22 volts DC

7. The measured voltage drops in a loop leading directly to the source voltage in a DC circuit are: +2.2 VDC, +15.0 VDC, -6.1 VDC, and +3.9 VDC. What is the source voltage?

a. +27.2 VDC
b. +15.0 VDC
c. -6.1 VDC
d. 21.1 VDC

8. The voltage dropped across a 10 k ohm resistor is 4 VDC. What is the current through the resistor? (DC current)

a. 4 amps DC
b. .1 milli-amps DC
c. .4 milli-amps DC
d. 1 amp DC

9. The voltage dropped across a resistor is 8.6 volts DC. If the measured current through the resistor is 20 ma, what is the value of the resistor?

a. 10 k ohms
b. 47 k ohms
c. 43 k ohms
d. 430 ohms

10. Kirchoff's law states that the algebraic sum of the voltage drops in any closed loop equals the source resistance.

a. True
b. False

11. Calculate the total current in a parallel circuit that has five 5k ohm resistors in parallel if the source voltage is 10 volts DC:

a. 10 ma
b. 2 amps
c. 5 ma
d. 2 ma

12. The total voltage in a parallel circuit is equal to the sum of the voltages in the circuit.

a. True
b. False

13. The total resistance of a 22 k ohm and 47 k ohm resistor in parallel is:

a. 150 ohms
b. 69 k ohms
c. 15 k ohms
d. 330 k ohms

14. The total resistance of three 33 k ohm resistors in parallel is:

a. 100 k ohms
b. 11 k ohms
c. 33 k ohms
d. 330 k ohms

15. The initials EMF stand for:

a. Electro Mechanical Force
b. resistance
c. Electro Motive Force
d. Electro Motive Power

16. Calculate the total power dissipated in a series circuit that has five equal resistors of 22 k ohms each if the current through the circuit is 20 ma.

a. 8.8 mWatts
b. 8.8 Watts
c. 44 Watts
d. 22 Watts

17. Power in a resistive circuit is dissipated as heat.

a. True
b. False

18. The total power in a circuit is calculated by multiplying the __________ by the ____________.

a. resistance , voltage
b. total resistance, current
c. voltage, voltage
d. total resistance, current squared

19. Generating a EMF by applying heat to the junction of two un-a-like metals is known as:

a. the photovoltaic effect
b. the electro-chemical effect
c. the Seebeck effect
d. friction

20. Generating an EMF by converting photons of light into electrical energy is known as the:

a. the photovoltaic effect
b. the electro-chemical effect
c. the Seebeck effect
d. Electro magnetic effect

21. The formula that we would use to calculate one time constant for the charge of an R-C circuit is:

a. R x C = 1 TC
b. I / C = 1 TC
c. R / C = 1 TC
d. R x 1 = 1 TC

22. If the DC source voltage of a series R-C circuit is 12 volts, what is the voltage across the RESISTOR after the first time constant?

a. 15.12 volts DC
b. 24 volts
c. 8.88 volts
d. 4.44 volts

23. In a series R-C circuit, in which the resistor is 10 k ohms and the capacitor is 2 ufd, how long will it take to charge the capacitor to 99% of the source voltage? (answer in engineering notation)

a. .1 sec
b. 1 u sec
c. 20 m sec
d. 1000 sec

24. In a series R-C circuit that is sourced by 12 volts DC, what is the value of a capacitor that charges to 7.56 volts in 20 ms if the value of the resistor is 100 k ohms.

a. 20 pfd
b. .1 ufd
c. .2 ufd
d. 100 ufd

25. If a capacitive circuit has a .1 ufd capacitor and is supplied by an AC voltage at 100 k Hz, what is the capacitive reactance?

a. 16 ohms
b. 16 ufd
c. 63 ohms
d. 63 m ohms

26. The value of inductive reactance or capacitive reactance in any given circuit is a function of the applied frequency.

a. True
b. False

27. When frequency decreases, inductive reactance __________, and capacitive reactance __________.

a. increases, decreases
b. decreases, increases

28. In a resistance-capacitance series circuit, the resistance is 1 k ohms and the time of charge to 63% (62.5%) of the source DC is 1 milli-second. What is the value of the capacitor?

a. 10 ufd
b. 1 milli fd
c. 1 ufd
d. 220 ufd

29. In a series R-L circuit, the frequency of the applied AC is 80 kHz. The inductance of the inductor is 20 milli henrys, and the resistor is 10 k ohms. What is a the impedance of the circuit?

a. 125.68 meg ohms
b. 125.68 ohms
c. 14.176 k ohms
d. .008 ohms

30. In a series R-C circuit, the time on the oscilloscope for one cycle of the source AC voltage is 20 milli seconds. The measured phase shift is 2.5 milli seconds. What is the phase angle?

a. 90 degrees
b. 10 degrees
c. 180 degrees
d. 45 degrees

31. In any transformer, the _____ in the primary equals the ______ in the secondary minus ________.

a. voltage, current, power
b. power, power, losses
c. voltage, voltage, losses
d. current, current, losses

32. A properly designed power transformer should be part of the load.

a. True
b. False

33. In a step-down transformer, with a turns ratio of 4:1, the voltage in the primary is 440 VAC. What is the voltage in the secondary?

a. 440 VAC
b. 27.5 VAC
c. 55 VAC
d 110 VAC

34. In a transformer, the voltage in the primary is 440 VAC. The apparent power in the primary is 220 watts. The secondary current is 2 amps. What is the turns ratio? Is the transformer step-up or step-down?

a. 1:4, step-up
b. 1:4, step-down
c. 4:1, step-up
d. 4:1, step-down

35. In a step-down transformer, the primary current is 1 amp, and the power in the secondary is 1000 watts. If the turns ratio is 10:1, what is the secondary voltage?

a. 1000 VAC
b. 200 VAC
c. .1 VAC
d. 100 VAC

36. In a DC motor, the field current primarily determines __________ while the armature current primarily determines __________.

a. speed, torque
b. torque, power
c. torque, speed
d. power, losses

37. In a universal motor, the field windings are in ______ with the ________.

a. parallel, stator
b. series, stator
c. parallel, armature
d. series, armature

38. A universal motor can be used on both AC and DC.

a. True
b. False

39. The nominal value of the drop across the P-N junction of a forward biased silicon junction diode is:

a. the source voltage
b. .2 - .3 volts
c. .6 -.7 volts
d. 1.5 volts

40. PIV in a diode stands for the:

a. maximum voltage the diode can withstand when it is reverse biased.
b. maximum voltage the diode can withstand when it is forward biased.
c. potential instantaneous voltage
d. primary inverted voltage

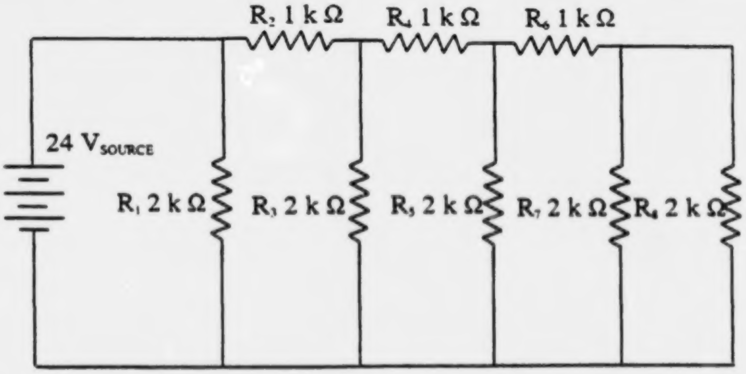
41. When the field of a shunt field DC motor is weakened, the motor speed:

a. remains the same
b. increases
c. decreases

42. A zener diode regulates voltage when it is:

a. forward biased
b. reverse biased

43. In the below circuit what is the total current (IT), total resistance (RT), and the voltage drop across R7? (VR7)



a. 24 mA, 2 k ohms, 12 volts
b. 12 mA, 1 k ohms, 3 volts
c. 24 mA, 1 k ohms, 3 volts
d. 24 mA, 2 k ohms, 1.5 volts

44.. If a resistor is to be selected to be used in a circuit that has a voltage of 12 volts DC and will draw .2 amp, the wattage rating of the resistor should be at least:

a. 5 watts
b. 2 watts
c. 1 watt
d. 1/2 watt

45. While measuring a circuit you find that the current through the circuit is 2 milliamps and the measured voltage is 15 volts DC. The resistance of the circuit is:

a. 10 k ohms
b. 75 k ohms
c. 7.5 k ohms
d. 7.5 amps

46. Using a meter, you find that a circuit measures 100 ohms. After testing the current, you find that 100 milliamps is flowing through the resistance. the voltage drop across the circuit is:

a. 10000 volts
b. 1 volt
c. 10 volts
d. 10 ohms

47. The measured resistance of a circuit is 220 k ohms. If a voltage of 15 volts is to be applied to the circuit, the current through the circuit should be:

a. 68 microamps
b. 6.8 milliamps
c. 68 amps
d. 6.8 volts

48. A capacitor that is labeled 10 ufd and 25 WV is:

a. a 10 times 25 micro farad capacitor
a. a 25 micro farad capacitor
c. a 10 micro farad capacitor rated at 25 working Volts
d. a 25 farad capacitor

49. A 2 ufd capacitor that is to be charged to 15 volts DC through a 10k ohm resistor will be charged to what value in 20 milliseconds?

a. approximately 9.4 volts
b. 15 volts
c. approximately 7.5 volts
d. 10 ohms

50. An inductor that is labeled 20 mhy is:

a. 20 henrys
b. 2.0 micro henrys
c. 20 milli henrys
d. 20 hertz

51. An inductor that provides 1 volt of back EMF for a current of 1 amp that changes at a rate of 1 hertz is a:

a. 1 henry inductor
b. 10 henry inductor
c. .1 henry inductor
d. 1 ohm inductor

52. To calculate the current and voltage in a simple AC circuit that has nothing but resistive components, the technician should use:

a. trigonometry, vectors, and Ohm's Law
b. algebra and Ohm's Law
c. Thevinin's Theorem
d. Kirchoff's Law

53. To calculate the current and voltage in a AC circuit that contains resistance, inductance, and capacitance, the technician should use.

a. trigonometry, vectors, and Ohm's Law
b. algebra and Ohm's Law
c. Thevinin's Theorem
d. Kirchoff's Law

54. In an resistive-inductive series circuit, the measured voltage will ______ the measured current.

a. lead
b. lag
c. cancel

55. In an resistive-capacitive series circuit, the measured voltage will ______ the measured current.

a. lead
b. lag
c. cancel

56. In a complex inductive or capacitive AC circuit, the term phase angle refers to:

a. the angle of the components in a complex circuit
b. the number of degrees in one half of a sine wave
c. the amount of degrees in a full sine wave
d. the amount of degrees difference between voltage and current

57. The term impedance (Z) is used to describe:

a. the flow of current in a complex AC circuit
b. the total resistance to current flow in a complex AC circuit
c. the total voltage in a complex AC circuit
d. the phase angle in a complex AC circuit

58. The term inductive reactance is used to describe

a. the resistance to current flow of an inductor
b. the phase angle of an inductor
c. the inductance of an inductor
d. the amount of henrys of an inductor

59. The term capacitive reactance is used to describe

a. the resistance to current flow of a capacitor
b. the phase angle of a capacitor
c. the capacitance of a capacitor
d. the amount of farads of an capacitor

60. At resonance, a series inductive, capacitive, resistive circuit is almost:

a. pure resistance
b. pure inductive reactance
c. pure capacitive reactance
d. an infinite impedance

61. At resonance, a parallel inductive and capacitive circuit is almost:

a. pure resistance
b. pure inductive reactance
c. pure capacitive reactance
d. an infinite impedance

62. In the lab, the resistance reading on the analog meter changed with each resistance scale of the meter when measuring the forward resistance of a junction diode. This is because the internal _____ of the diode changed whith the applied _____.

a. voltage, current
b. resistance, current
c. resistance, voltage
d. voltage, resistance

63. The barrier potential of a silicon junction diode is approximately:

a. 1 volt
b. .2 - .3 volt
c. .6 -.7 volt
d. 3 volts

64. The barrier potential of a germaninum junction diode is approximately:

a. 1 volt
b. .2 - .3 volt
c. .6 - .7 volt
d. 3 volts

65. In the lab, when measuring the forward conduction of a silicon junction diode, the reading on the diode scale of the ***digital*** meter was the:

a. diode's forward resistance
b. diode's current
c. diode's PIV
d. diode's forward voltage drop

66. In the lab, the reason that the analog meter did not measure resistance when the black lead was placed on the cathode of the diode, and the red lead was placed on the anode of the diode, was because:

a. the black lead of the meter reads positive voltage
b. the meter could not exceed the barrier potential
c. the diode was damaged
d. the PIV was wrong

67. A 24 watt, 12 volt zener diode will conduct a maximum current of:

a. 1 amp
b. 2 amps
c. 12 amps
d. 3 amps

68. A zener diode regulates voltage by:

a. magic
b. changing its internal voltage
c. PIV
d. changing its internal resistance

69. the measured current in one leg of a balanced three phase 440 volt AC circuit is 30 amps. The circuit is totally resistive. What is the total power in the circuit?

a. 22.8 kw
b. 40 kw
c. 13.2 kw
d. 440 kw

70. Each leg of a three phase AC circuit has a phase relationship to the other legs of:

a. 60°
b. 90°
c. 120°
d. 90°

71. In a 208 VAC , three Phase Wye circuit, the voltage from one phase to the neutral is:.

a. 208 VAC
b. 208 kw
c. 440 VAC
d. 120 VAC

72. The main reason to energize the shunt field of a DC shunt field motor with a different voltage source is to:

a. make the motor run faster
b. improve the low speed torque
c. improve the current flow
d. none

73.. If the shunt field of a shunt field DC motor decreases, the motor speed will:

a. increase
b. decrease
c. remain the same
d. stop

74. If the capacitor in a split phase capacitive start AC motor fails, (opens):

a. the motor will burn up
b. the motor will overspeed
c. the motor will stop
d. the motor will not start

75. The working voltage of the capacitor in a capacitor-start, capacitor-run, split phase AC motor is typically _______ than that of a capacitor start AC motor.

a. higher
b. lower

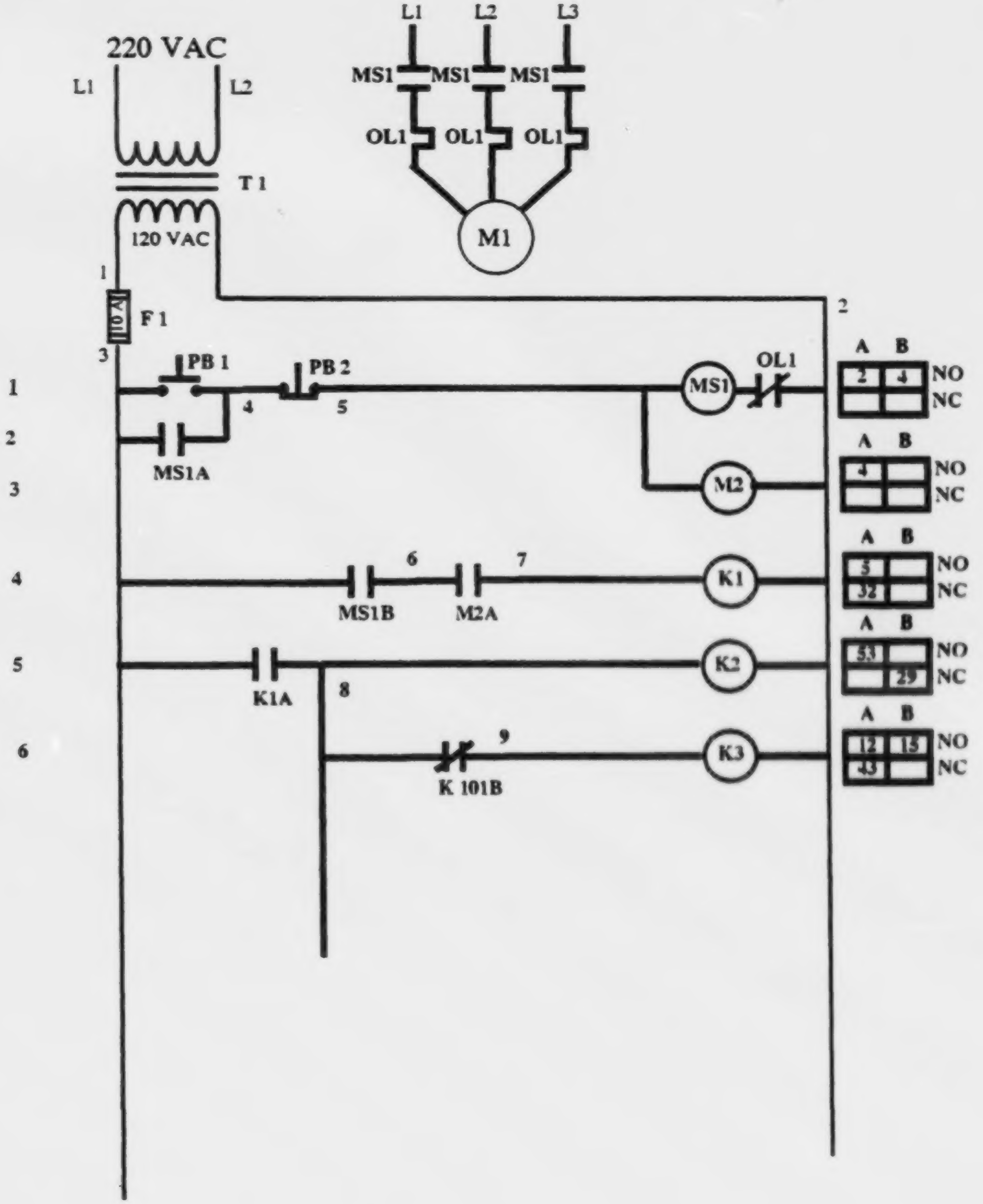
76 In a three phase inductive AC motor, reversing the leads on one phase of the motor will make it reverse direction.

a. true
b. false

77. Loosing one phase on a three phase AC inductive motor will:

a. cause the motor to stop
b. cause the motor to run rough
c. cause the motor to speed up

The next eight questions refer to the below circuit


220 VAC
L1
L2
T1
120 VAC
1
10A
F1
3
2
L1
L2
L3
MS1
MS1
MS1
OL1
OL1
OL1
M1
1
2
3
4
5
6
PB 1
PB 2
4
5
MS1A
MS1
OL1
M2
6
7
MS1B
M2A
K1
K1A
8
K2
9
K 101B
K3
A B
2 4 NO
NC
A B
4 NO
NC
A B
5 NO
32 NC
A B
53 NO
29 NC
A B
12 15 NO
43 NC

78. If the voltage measured across the normally closed B contacts of relay K101 is 120 volts AC, the relay contacts are:

a. open
b. closed

79. If the voltage measured across the coil of relay K3 is 120 volts AC, and PB 1 is not pushed, the normally open A contacts of relay MS1 are:

a. open
b. closed

80. If the voltage measured across the coil of relay K3 is 120 volts AC, and PB 1 is not pushed, then the purpose of PB 2 is to:

a. close PB 1
b. energize K3
c. de-energize K3
d. de-energize M1

81. If the overload OL 1, senses excessive current on motor M1, and opens up, then the voltage drop across the coil of relay K2 will be:

a. 0 volts
b. 120 volts AC
c. 24 volts
d. 220 volts AC

82. The turns ration on T1 is approximately:

a. 4:1
b. 1:4
c. 2:1
d. 1:2

83. If fuse F1 blows, the voltage drop across contacts K1A will be :

a. 0 volts
b. 120 volts AC
c. 24 volts
d. 220 volts AC

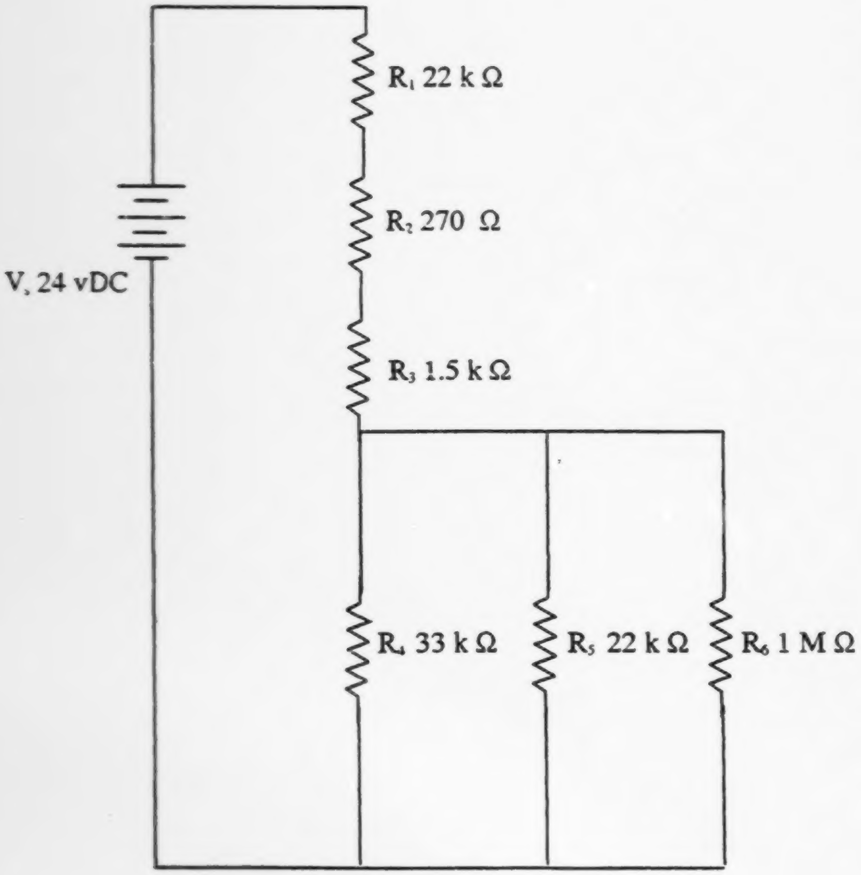
84. if relay K2 is energized, the motor M1 will be:

a. turning
b. stopped

85. If relay K101 is a 24 volt DC relay, and the voltage drop across the coil of K3 is is 0 volts, the voltage drop across the coil of K101will be:

a. 0 volts
b. 120 volts AC
c. 24 volts
d. 220 volts AC

The next 5 questions refer to the following diagram


R_1 22 k Ω
R_2 270 Ω
V, 24 vDC
R_3 1.5 k Ω
R_4 33 k Ω
R_5 22 k Ω
R_6 1 M Ω

86. The voltage drop across resistor R~~2~~3 is 1.5 volts DC, if resistor R6 is suspected of being the problem has it:

a. shorted
b. open
c. decreased in resistance
d. increased in resistance
e. remained the same

87. The voltage drop across resistor R1 is 14.35 volts DC if resistor R4 is suspected of being the problem has it:

a. shorted
b. open
c. decreased in resistance
d. increased in resistance
e. remained the same

88. The voltage drop across resistor R6 is 4.5 volts DC if resistor R2 is suspected of being the problem has it:

a. shorted
b. open
c. decreased in resistance
d. increased in resistance
e. remained the same

89. The current through resistor R2 is 1.65 mA DC, if resistor R1 is suspected of being the problem has it:

a. shorted
b. open
c. decreased in resistance
d. increased in resistance
e. remained the same

90. The current through resistor R6 is 8.5 uA DC, if resistor R5 is suspected of being the problem has it:

a. shorted
b. open
c. decreased in resistance
d. increased in resistance
e. remained the same

Final Exam, Manufacturing Technology 205- Advanced Industrial Electronics

1. Multiple Choice: A material composed of pure silicon has a typical resistance of:

a. 1 meg ohms/ cm^3
b. 20 ohms/ cm^3
c. 200 k ohms/cm^3
d. 65 ohms/cm^3

2. Fill in the Blank: An Industrial Electronics Technician should assume that all current carrying wires are:

a. at safety ground potential
b. grounded
c. above safety ground potential
d. safe to handle

3. Multiple Choice: When testing a bipolar transistor with an analog meter, the resistance reading from collector to emitter is:

a. very low in both directions
b. very high in both directions
c. low from collector to emitter, high from emitter to collector
d. high from collector to emitter, low from emitter to collector

4. Multiple choice: When a bipolar power transistor operates at high currents in the class A mode:

a. it will fail from the effects of thermal runaway
b. it will dissipate little power
c. it will fail from the effects of reach through
d. it will become hot

5. Multiple choice: When a bipolar power transistor operates at high currents in the class C mode:

a. it will fail from the effects of thermal runaway
b. it will dissipate little power
c. it will fail from the effects of reach through
d. it will become hot

6. Multiple choice: In an open collector Integrated circuit, if the collector load resistor is removed from the circuit, the output of the chip will switch from:

a. 0 vdc to source.
b. plus source to minus source.
c. it will not switch at all

DO NOT WRITE ON THE EXAM!

7. Multiple Choice: When testing a bipolar transistor with an analog meter, the resistance reading from base to collector is:

a. very low in both directions
b. very high in both directions
c. low in one direction, high in another direction
d. cannot be measured

8. Fill in the blanks. Relay drop-out current is usually considerably __________ than relay pick-up current.

a. lower
b. higher

9. Multiple choice. If the filter capacitor in a full wave power supply fails open:

a. the frequency of the ripple will decrease.
b. the voltage will drop to zero
c. the peak to peak value of the ripple will increase.
d. the frequency of the ripple will increase.

10. Multiple choice: Which part of a power supply can store a charge for an extended period of time?

a. the rectifiers.
b. the transformer.
c. the load resistor.
d. the filter capacitors.

11. Multiple choice: Why is it not possible to use a 150 volt (peak) MOV on a 120 VAC (rms) circuit?

a. because inductive transients will damage the MOV.
b. because the high current surges will damage the MOV.
c. because the peak voltage of 120 VAC is higher than 150 volts.

12. Multiple choice. The two undesired effects which are caused by harmonic energy in switch mode power supplies are:

a. Common mode noise and differential mode noise.
b. poor regulation and heating of components.
c. lack of EMI and no harmonic energy.
d. none of the above.

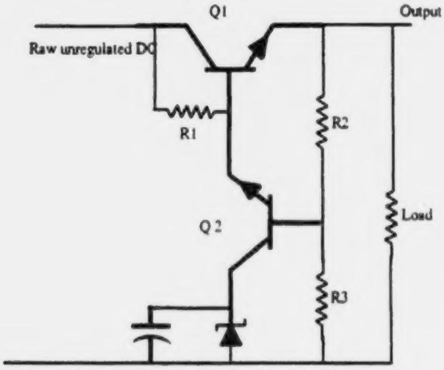
13. Fill in the blanks. If you are observing the drive signal at the base of the switching transistor, and the load on the switching power supply increases, the duty cycle of the drive signal will_______________.

a. increase
b. decrease
c. remain the same

14. Multiple choice. When measuring 'hot' circuits with grounded test equipment, the technician must guard against:

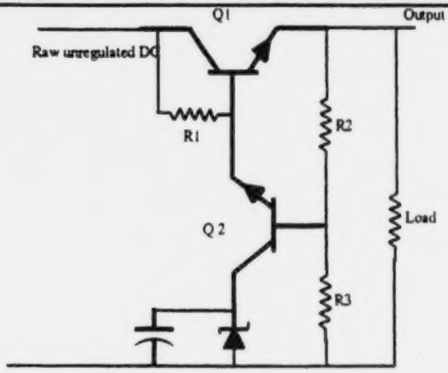
a. high resistance.
b. ground loops and high ground fault currents.
c. common mode rejection ratio.
d. none of the above.

15. Word problem. In the diagram, what can be expected to happen to the output voltage if transistor Q1 opens?



a. the voltage drops to zero
b. the voltage increases to raw unregulated DC
c. the voltage remains the same

16. Word problem. In the diagram, if transistor Q1 shorts, what is the output voltage?



a. the voltage drops to zero
b. the voltage increases to raw unregulated DC
c. the voltage remains the same

17. Multiple Choice: When testing a bipolar transistor with an analog meter, the resistance reading from base to emitter is:

a. very low in both directions
b. very high in both directions
c. low in one direction, high in another direction
d. cannot be measured

18. Multiple choice: An emitter follower amplifier has a current gain of:

a. zero
b. less than 1
c. equal to the Hfe of the transistor.
d. between zero and 1.

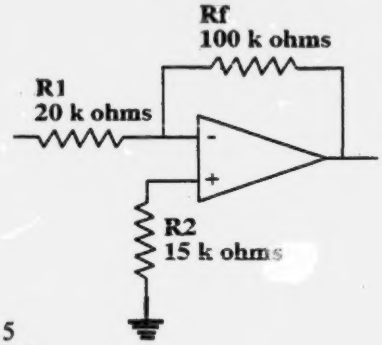
19. Multiple choice: A differential amplifier responds to:

a. the sum of two inputs.
b. the square of the sum of two inputs
c. the difference between two inputs.
d. one input.

20. Both UJTs and PUTs are used to trigger _______ and ______

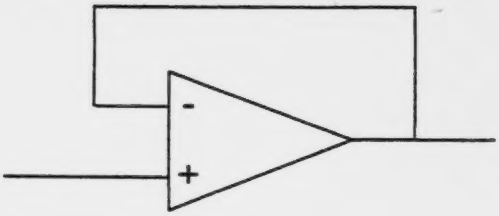
a. bipolar and monopolar transistors
b. SCRs and TRIACs
c. Diodes and resistors
d. all the above

21. Word problem: Calculate the dc voltage gain in the below inverting amplifier.



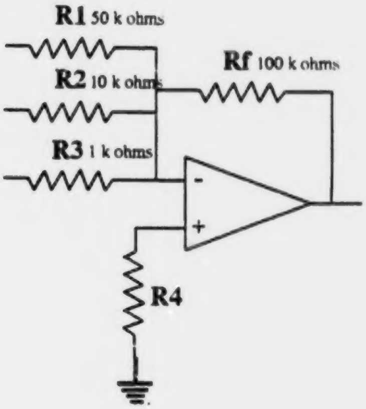
a. 5
b. 100
c. 20
d. 2

22. Word problem: Calculate the dc voltage gain in the below non-inverting amplifier.



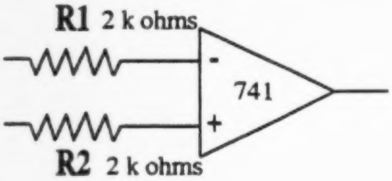
a. 1
b. 100
c. 20
d. 2

23. Word problem: Calculate the dc voltage gains in the below inverting amplifier for loop R1-Rf, R2-Rf, R3-Rf.


R1 50 k ohms
R2 10 k ohms
Rf 100 k ohms
R3 1 k ohms
-
+
R4

a. 100, 50, 5
b. 20, 2, 100
c. 20, 50, 100
d. 2, 10, 100

24. Multiple choice: The dc voltage gain in the below operational amplifier circuit is approximately:



a. 100
b. 20
c. 200,000
d. 1

25. Multiple choice: Refer to page 140 of Industrial Electronics and Robotics. At a frequency of 1 k Hz, the intrinsic gain of a 741 op amp is:

a. 1000
b. 200,000
c. 100
d. 1

26. Fill in the blanks: The _____________ _____________ manuals should first be checked before attempting any servicing.

a. Program log
b. Equipment maintenance
c. basic theory
d. dissembly

27. Fill in the blanks: Verification of all _________ voltages is an important early step in servicing any control.

a. digital
b. analog
c. power supply
d. pulse width modulated

28. True/False: The controversy surrounding measurement of circuits that have unequal reference points, centers upon the grounding of the test equipment.

a. true
b. false

29. Word problem: The maximum reverse current for a 12 watt 12 volt zener diode is:

a. .5 amps
b. 1 amp
c. 2 amps
d. 0 amps

30. Multiple choice: A perfect switching transistor, in the saturated condition, would show a collector to emitter voltage drop of:

a. The source voltage
b. zero volts
c. zero ohms
d. zero amps

31. Multiple choice: In a SCR, commutation is achieved by:

a. reversing the current through the device.
b. removing the source voltage.
c. the AC voltage passing through zero.
d. all of the above

32. Multiple choice: In an open collector integrated circuit, the external collector load resistor is used to:

a. bias the collector.
b. provide a current source for the next device.
c. enable the transistor to switch to source voltage.
d. all of the above.

33. Multiple choice: Excessive hum on an AC relay or contactor may indicate that:

a. the armature of the device is not seated properly.
b. the wrong frequency of AC is being used.
c. the AC voltage is backwards.
d. the contacts are dirty.

34. Multiple choice: In the specifications for a rectifier, PIV or PRV stands for:

a. the maximum voltage the diode can withstand when it is forward biased
b. Primary Intrinsic standoff Voltage.
c. The maximum voltage the diode can withstand when it is reverse biased
b. none of the above.

35. True/False: Junction Field Effect transistors are normally reverse biased at the gate to drain/source junction.

a. true
b. false

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36. Multiple choice: The voltage drop across a diode that is forward biased is typically:

a. the source voltage.
b. .2 to .7 volts.
c. zero volts.
d. 1 volt.

37. Multiple choice: The type of coupling found in DC amplification is:

a. capacitive coupling.
b. inductive coupling.
c. direct coupling.
d. all of the above.

38. Multiple choice: The types of semiconductors most often used in the power switching stage of a Pulse Width Modulated drive amplifier are:

a. MOS FETS and Darlington transistors.
b. SCRs and Triacs
c. diodes and operational amplifiers.
d. microprocessors

39. Fill in the blanks: A method used to gate three phase variable frequency power inverters sequentially is to use a __________counter.

a. decade
b. binary
c. ring

40. True/False: If two or more semiconductors are damaged in a three phase power inverter, the problem is most likely in the digital circuitry of the ring counter.

a. true
b. false

41. Multiple Choice: Weakening the shunt field of a DC motor will cause the motor speed to:

a. increase
b. decrease
c. remain the same

DO NOT WRITE ON THE EXAM!

42. Multiple choice: Handshaking in an RS-232-C communications interface can be implemented in:

a. software.
b. hardware.
c. protocol.
d. a and b above.

43. Fill in the blanks: The average number of bits transmitted over an RS-232-C communications interface per a unit time is known as the __________ rate.

a. data
b. baud
c. terminal
d. protocol

44. Multiple choice: The type of feedback employed in the minor servo loop is always:

a. position feedback
b. velocity feedback
c. positive feedback
d. acceleration feedback

45. Multiple choice: The position lag in a major servo loop is a function of the:

a. mechanism
b. following error
c. velocity feedback
d. all of the above

46. Multiple choice: Following error is a function of the _______ of the servo system.

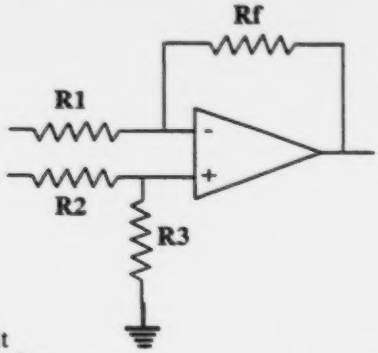
a. gain
b. type of positioning feedback
c. type of velocity feedback
d. positive feedback

47. Multiple choice: A tachometer in a minor servo loop is used:

a. to determine position.
b. to eliminate following error.
c. to increase the gain.
d. to provide velocity stability for the system.

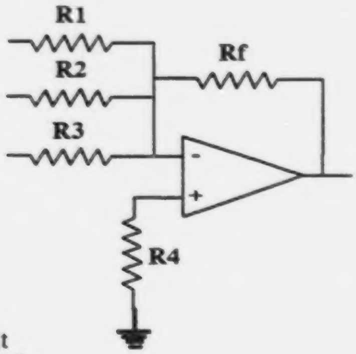
DO NOT WRITE ON THE EXAM!

48. Multiple choice: The operational amplifier circuit depicted below is a:



a. unity gain circuit
b. summation amplifier
c. comparator
d. subtraction amplifier

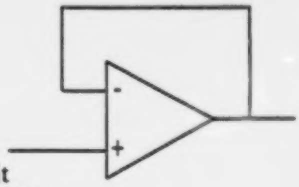
49. Multiple choice: The operational amplifier circuit depicted below is a:



a. unity gain circuit
b. summation amplifier
c. comparator
d. subtraction amplifier

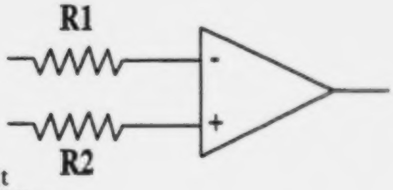
DO NOT WRITE ON THE EXAM!

50. Multiple choice The operational amplifier circuit depicted below is a:



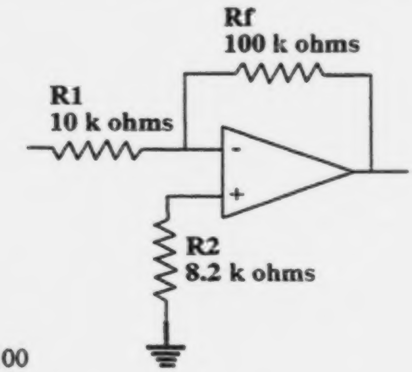
a. unity gain circuit
b. summation amplifier
c. comparator
d. subtraction amplifier

51. Multiple choice The operational amplifier circuit depicted below is a:



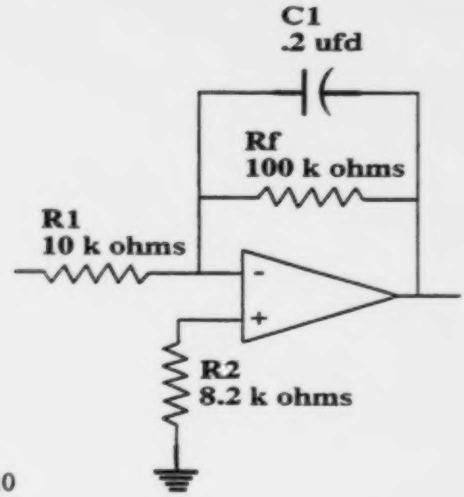
a. unity gain circuit
b. summation amplifier
c. comparator
d. subtraction amplifier

52. Multiple choice The gain of the operational amplifier circuit depicted below is:



a. 100
b. 10
c. 100,000
d. 1

53. Multiple choice: At a frequency of 100 k Hz, the gain of the below operational amplifier circuit is approximately:



a. 10
b. 1
c. 2
d. 0

54. Multiple choice: A stepper motor that has a step angle of 1.8 degrees has:

a. 90 steps per revolution
b. 100 steps per revolution
c. 360 steps per revolution
d. 200 steps per revolution

55. Multiple choice: _______ refers to the smallest increment of motion that a stepper motor can move.

a. RPS
b. RPM
c. step angle
d. one thousandth of an inch

56. True/False: Instability in a continuous path closed loop servo system can always be attributed to the tach in the minor servo loop.

a. true
b. false

DO NOT WRITE ON THE EXAM!

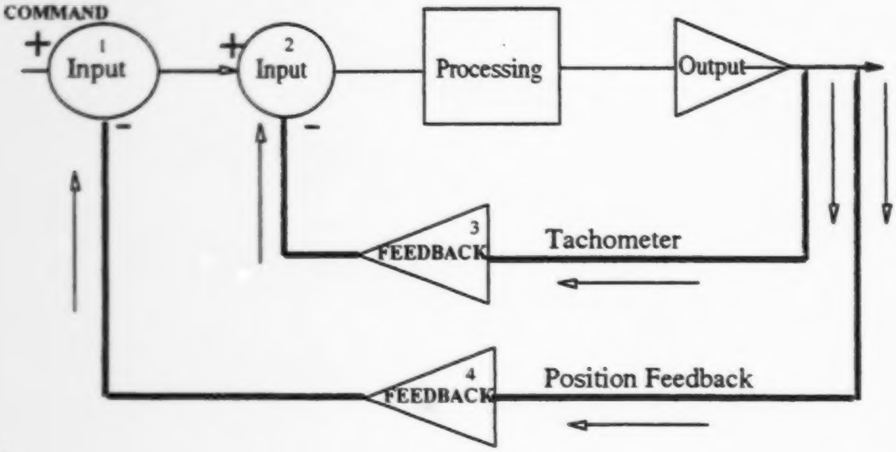
57. Which of the following is NOT a type of feedback used in the major (positioning) servo loop?

a. resolver
b. tachometer
c. rotary optical encoder
d. linear optical encoder

58. True/False: A full wave SCR power controller can be used to control both motors and resistive type devices.

a. true
b. false

59. Number the components: The components of the positioning loop are:


COMMAND
+
-
1
Input
-
+
2
Input
-
Processing
Output
3
FEEDBACK
Tachometer
4
FEEDBACK
Position Feedback

a. 1,2
b. 1,3
c. 1,4
d. 2,3

60. Number the components: Refer to the above. The components of the stability loop are:

a. 1,2
b. 1,3
c. 1,4
d. 2,3

61. Multiple choice: A three phase variable frequency inverter motor drive is used to run:

a. a DC shunt field motor
b. a capacitive start AC motor
c. a Three phase inductive AC motor
d. a permanent magnet DC motor

62. True/false: The terminals labeled F1 and F2 on a motor control for a shunt field motor are provided to control the armature.

a. true
b false

63. Multiple choice: The type of amplification used in a digital circuit is:

a. class A
b. class B
c. class C

64. Multiple choice: The type of amplification used in an analog circuit is:

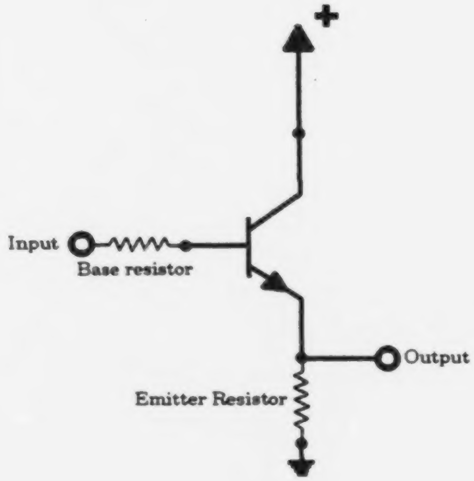
a. class A
b. class B
c. class C

65. Multiple choice: The type of amplification used in the output stage in an operational amplifier is:

a. class A
b. class B
c. class C

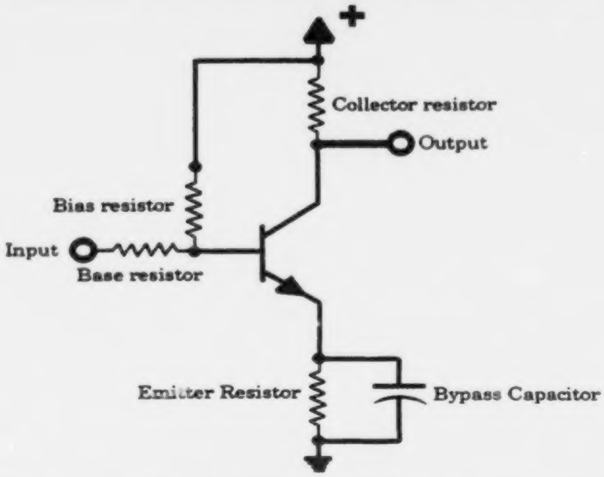
66. Multiple choice: The type of transistor amplifier depicted below is:

a. common emitter
b. common collector
c. common base



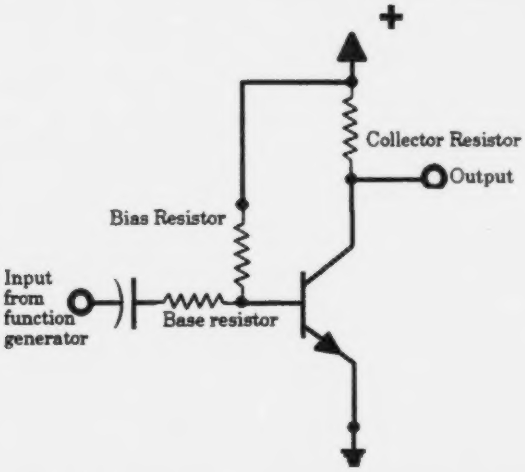
67. Multiple choice: The type of transistor amplifier depicted below is:

a. common emitter
b. common collector
c. common base


+
Collector resistor
Output
Bias resistor
Input
Base resistor
Emitter Resistor
Bypass Capacitor

68. Multiple choice: The type of transistor amplifier depicted below is:

a. common emitter
b. common collector
c. common base


+
Collector Resistor
Output
Bias Resistor
Input from function generator
Base resistor

69. Multiple choice: The bypass capacitor in the amplifier in question 67 is used to:

a. improve the stability of the amplifier circuit
b. increase that AC gain of the amplifier circuit
c. increase the DC gain of the amplifier circuit

70. Multiple choice: The following error in a closed loop servo for a CNC machine is specified as being .1 mil/inch/min. What is the following error at a velocity of 56 inchs/min (1 mil = .001 inches)

a. .00056
b. .0056
c. .056
d. .56

71. Multiple choice: In a transistor amplifier, the transistor amplifies by lowering or raising its:

a. internal voltage
b. internal resistance
c. base voltage
d. emitter voltage

72. Multiple choice: To amplify a signal that has common mode noise on it, the amplifier of choice would be:

a. a differential amplifier
b. a common emitter amplifier
c. a common base amplifier
d. a transistor amplifier

73. True false: It is acceptable to connect one ground lead of a dual trace oscilloscope to L1 or L2 of the AC line voltage, and the ground lead of the other probe to logic common.

a. true
b. false

74. Fill in the blanks: To switch on a SCR, the _______ to ________ junction must be forward biased.

a. gate to cathode
b. gate to anode
c. base to emitter
d. base to collector

75. Fill in the blanks: A programmable unijunction transistor (PUT) switches when the gate voltage reaches the percentage of the source voltage determined by the ________ _______ ________.

a. program voltage
b. gate b1 and b2
c. intrinsic standoff ratio
d. voltage current and resistance

76. A capacitor is used in a UJT or PUT to _____ the firing voltage.

a. set
b. prevent
c. time
d. ground

77. In a Traic circuit which is used to control an inductive load, a diac is used to prevent:

a. triggering
b. snap on
c. base current
d. AC voltage

78. One of the main differences between using a Traic to control AC and using a SCR to control AC, is that the Triac controls _____ _____ AC whereas the SCR _____ _____ AC.

a. high voltage, low voltage
b. full wave, half wave
c. low voltage, high voltage
d. source voltage, load voltage

79. Using a SCR on DC requires that the _____ be removed form the SCR to ______ the device.

a. power, commutate
b. frequency, change
c. resistance, gate
d. grid, cascade

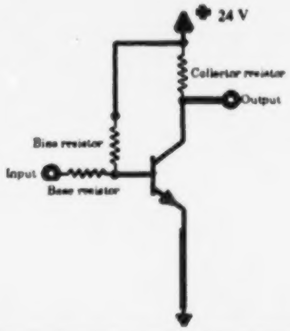
80. PUT stands for _____ _____ _____

a. A verb in english
b. portable unit test
c. A gerund in english
d. programmable unijunction transistor

81. the main difference between the UJT and the PUT is that the UJT firing voltage is ______ whereas the PUT firing voltage can be _______:

a. fixed, programmed
b. programmed, fixed
c. fixed, fixed
d. programmed, programmed

The next two questions refer to the below circuit


+ 24 V
Collector resistor
Output
Bias resistor
Input
Base resistor

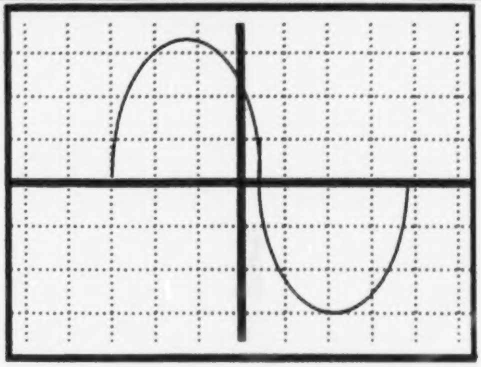
82. Multiple choice: When the transistor is in saturation, the voltage at the output of the circuit will be approximately:

a. 24 VDC
b. 12 VDC
c. 0 VDC
d. .7 VDC

83. Multiple choice: When the transistor is in cut off, the voltage at the output will be approximately:

a. 24 VDC
b. 12 VDC
c. 0 VDC
d. .7 VDC

The next four questions refer to the below diagram



84. Multiple choice: The vertical voltage scale setting on the oscope is 5V/DIV. The horizontal time setting on the oscope is 2 ms/DIV. In the first quadrant of the sine wave, what is the approximate phase angle at an instantaneous voltage of +15 volts?

a. 41 degrees
b. 100 degrees
c. 56 degrees
d. 90 degrees

85. Multiple choice: The vertical voltage scale setting on the oscope is 50V/DIV. The horizontal time setting on the oscope is 2 ms/DIV. What is the approximate RMS value of the AC?

a. 110 VAC
b. 155 VAC
c. 220 VAC
d. 440 VAC

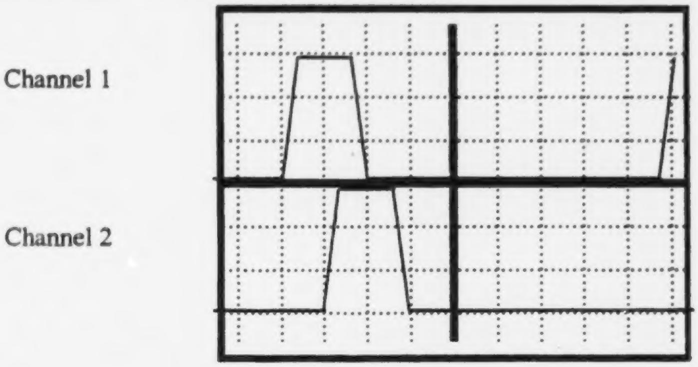
86. Multiple choice: The vertical voltage scale setting on the oscope is 5V/DIV. The horizontal time setting on the oscope is 10 us/DIV. What is the approximate frequency of the AC?

a. 200 MHz
b. 156 kHz
c. 156 MHz
d. 200 kHz

87. Multiple choice: The vertical voltage scale setting on the oscope is 5V/DIV. The horizontal time setting on the oscope is 2 ms/DIV. What is the approximate instantaneous voltage at a phase angle of 168.75 degrees?

a. 17 volts
b. 30 volts
c. -15 volts
d. 11 volts

The next 6 questions refer to the below oscilloscope screen



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88. Multiple choice: The vertical voltage scale setting on the oscope is 2V/DIV. The horizontal time setting on the oscope is 10 us/div. What is the approximate frequency of the signal on channel 1?

a. 120 kHz
b. 120 MHz
c. 200 kHz
d. 12 kHz

89. True/false: The vertical voltage scale setting on the oscope is 1V/DIV. The horizontal time setting on the oscope is 10 us/div. Channel 1 of the scope is set up for a proper common reference at the large graduation. The signal on channel 1 is a good TTL signal.

a. True
b. False

90. Multiple choice: The vertical voltage scale setting on the oscope is 2V/DIV. The horizontal time setting on the oscope is 10 us/div. What is the approximate duty cycle of the signal on channel 1?

a. 24 %
b. 75 %
c. 10 %
d. 12 kHz

91. Multiple choice: The vertical voltage scale setting on the oscope is 2V/DIV. The horizontal time setting on the oscope is 10 us/div. What is the approximate rise time, low-to-high of the signal on channel 1?

a. 10 usec
b. 1 usec
c. 2 usec
d. 100 kHz

92. Multiple choice: The vertical voltage scale setting on the oscope is 2V/DIV. The horizontal time setting on the oscope is 100 ns/div. Assume that the signals on channel 1 and 2 are the input and output respectively, of a TTL gate circuit. What is the approximate propagation delay of the circuit?

a. 10 nsec
b. 100 nsec
c. 10 usec
d. 1 msec

93. Multiple choice: The vertical voltage scale setting on the oscope is 2V/DIV. The horizontal time setting on the oscope is 10 ms/div. What is the approximate phase shift of the signal on channel 2 with respect to channel 1?

a. 90 degrees
b. 8.6 degrees
c. 100 degrees
d. 180 degrees

94. Multiple choice: If the position feedback in the major servo loop of a continuous path or contouring servo loop is lost, the servo system will become a:

a. point to point servo
b. velocity servo
c. it will stop
d. none of the above

95. Multiple choice: If the velocity feedback in the major servo loop of a continuous path or contouring servo loop is lost, the servo system gain will :

a. increase
b. decrease
c. it will stop
d. remain the same

96. Multiple choice: If the servo system is designed to create accurate circles it must be:

a. a velocity servo
b. a point to point servo
c. a contouring or continuous path servo
d. none of the above

97. True/false: A PID controller can be designed to operate a bang-bang servo

a. true
b. false

98. Multiple choice: PID stands for:

a. parallel, integral, and division
b. proportional gain, integral, and derivative
c. proportional band, inversion, and derivative
d. proportional band integral and derivative

99. Multiple choice: Proportional band is the:

a. inversion of integral
b. reciprocal of gain times 100
c. the same as derivative
d. none of the above

100. Fill in the blanks: ______ accelerates the process, while ______ decelerates the process.

a. proportional band, gain
b. derivative, integral
c. integral, derivative
d. gain, proportional band

Final exam, Manufacturing Technology 210 -Hydraulics

1. A cylinder with a 5 inch bore, and a stroke of 10 inches receives a flow of 10 GPM. The cylinder rod velocity is approximately: (whole units-no decimal fraction)

a. 2.5 ipm
b. 250 ipm
c. 470 ipm
d. 118 ipm

2. A cylinder with an 5 inch bore and a stroke of 60 inches must extend in to its full length in one minute. Approximately how much flow is required? (whole units-no decimal fraction))

a. 20 gpm
b. 10 gpm
c. 5 gpm
d. 1 gpm

3. A hydraulic motor develops 1500 lbs/inch of torque at 800 rpm. What is the horsepower approximately? (Whole units-no decimal fraction)

a. 19 hp
b. 63 hp
c. 8 hp
d. 20 hp

4. A hydraulic pump delivers 50 GPM at 1000 psi. What is the horsepower of the pump? (to the nearest tens of horse power)

a. 50 hp
b. 1500 hp
c. 10 hp
d. 30 hp

5. The term DEADHEADING means:

a. the pressure is off
b. all actuators at stops and system pressure at relief setting
c. all actuators at stops and system pressure is zero
d. all actuators moving and systems pressure at maximum

6. When the orifice in a flow control valve is narrowed, the pressure drop across the restriction:

a. Increases
b. Decreases

7. When the orifice in a flow control valve is narrowed, the velocity of the oil through the restriction:

a. increases
b. decreases

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8. At the test bench, when the system pressure was set to 400 PSIG, and the pressure output of the system was connected directly to tank, the system pressure dropped to below 200 PSIG. The system pressure thus achieved, was the result of:

a. the capacity of the pump
b. the flow control
c. the friction of the oil flowing through the lines
d. the pressure drop in the pump

9. Cavitation in a hydraulic pump will:

a. reduce pump flow
b. damage the metal surfaces of the pump
c. interfere with lubrication of the pump
d. all the above

10. Pseudo cavitation occurs in a hydraulic pump when:

a. water is added to the hydraulic oil
b. the pressure is too high
c. the oil temperature increases
d. bubbles of entrained air in the oil expand and collapse

11. Pseudo cavitation is accompanied by

a. a drop in system pressure.
b. a loss of hydraulic oil.
c. a high pitched whining sound from the pump.
d. all of the above.

12. Which has the highest ABSOLUTE pressure

a. 7 inches of vacuum
b. 2 inches of mercury
c. 450 torr
d. 0 PSIG

13. The formula for force developed by a cylinder is:

a. $P = F/A$
b. $F = GPM \times 231$
c. $F = ma$
d. $F = P \times A$

14. A pressure relief valve in a hydraulic system works by:

a. reducing the flow of oil through the system
b. closing the flow of oil through the system
c. dumping excess pressure back to tank
d. dumping flow back to tank

DO NOT WRITE ON THE EXAM!

15. A pressure compensated flow control valve:

a. maintains a constant down stream pressure with varying flow
b. maintains a constant flow with varying down stream pressure
c. controls pressure

16. When the piston end of a 2:1 cylinder is pressurized to 500 PSIG, the rod end of a blocked cylinder will read a pressure of:

a. 250 psig
b. 1000 psig
c. 500 psig
d. 125 psig

17. When a tandem center valve which is connected tandem P to T is centered, the system pressure will be ________ than the relief valve setting.

a. lower
b. higher

18. The system pressure for a pneumatic system is set by the use of a:

a. pressure reducing valve
b. pressure relief valve
c. pressure compensated flow control valve
d. on/off gate valve

19. Part of the basic theory of operation of all hydraulic pumps is:

a. the inlet of the pump is an increasing volume
b. the outlet of the pump is an increasing volume
c. the inlet of the pump is a decreasing volume
d. the outlet of the pump is a constant volume

20. A movable swash plate in a piston pump provides the pump with the ability to:

a. change pressure
b. change displacement
c. both a and b
d. none of the above

21. A piston pump with a moveable swash plate is:

a. a vane pump
b. a uni-directional pump
c. a variable displacement pump
d. a fixed displacement pump

22. Part of the basic theory of operation of all hydraulic motors is:

a. the inlet pressure causes an increasing volume
b. the outlet pressure causes an increasing volume
c. the inlet pressure held constant with a decreasing volume
d. the outlet pressure held constant with a decreasing volume

23. If the drain line on a pilot operated valve becomes blocked

a. The valve will work normally
b. The valve will cease to work completely
c. The valve will work erratically

24. The pressure required to move an overhanging weight is 100 psig at the piston end of the cylinder. the bore of the cylinder is 2.5 inches. The overhanging weight weighs: (round off to nearest whole units)

a. 49 lbs
b. 491 lbs
c. 100 lbs
d. 2.5 lbs

25. Which pressure is the LOWEST ABSOLUTE pressure?

a. 15 inches of mercury
b. 15 inches of water
c. 7 inches of vacuum
d. 0 PSIG

26. A pressure reducing valve is:

a. a normally closed valve
b. a normally open valve

27. A sequence valve is:

a. a normally open valve
b. a normally closed valve

28. If the tank line on a pressure relief valve is blocked:

a. The valve will cease to work
b. the valve will work normally

29. The pressure at which a pressure control valve starts to open is called:

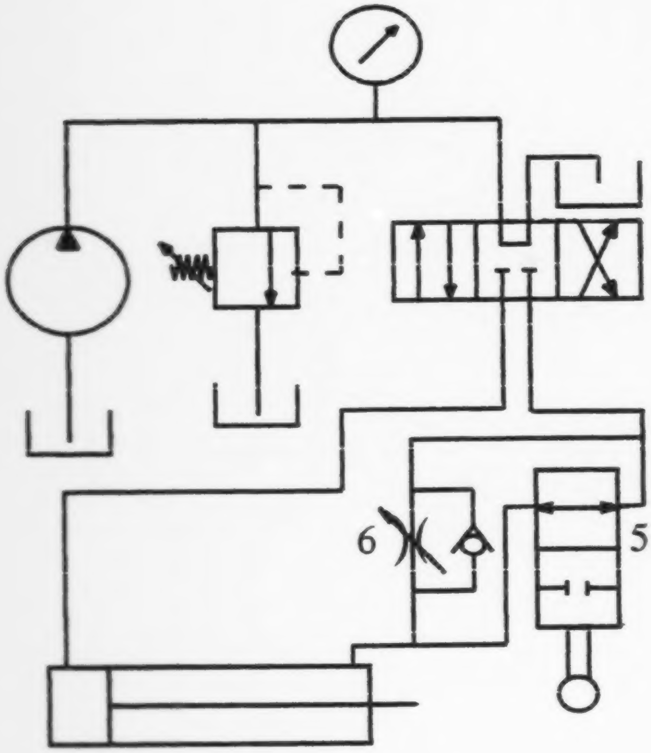
a. the control pressure
b. the back pressure
c. the cracking pressure

30. The volume of oil that a pump can move in one rotation is its:

a. pressure
b. displacement
c. gallons per minute

31. As the temperature of the oil in a hydraulic system starts to increase, the pressure drops in the system (increase/decrease):

a. increase
b. decrease



USE THIS DIAGRAM FOR THE NEXT 4 QUESTIONS

32. The above diagram represents.

a. a sequence circuit
b. a counter balance circuit
c. a rapid traverse/feed circuit
d. a deceleration circuit

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33. In the above diagram, flow control valve number 6 will set the :

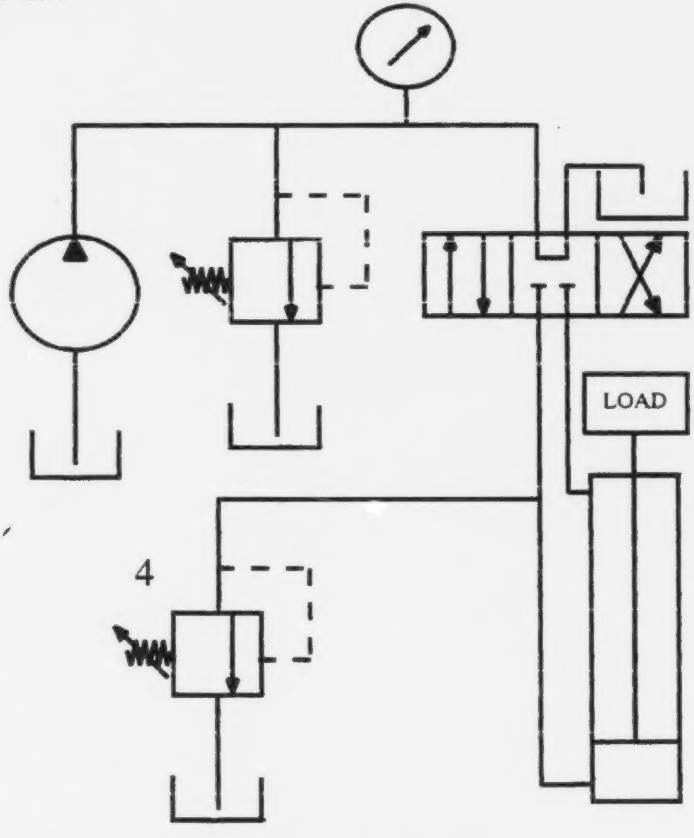
a. sequence pressure
b. counter balance pressure
c. feed speed
d. deceleration

34. In the above diagram, the check valve in parallel with flow control number 6 will open when the cylinder:

a. extends
b. retracts

35. In the above diagram, when the cylinder is extending, and valve number 5 closes, oil will flow through the:

a. check valve
b. flow control valve



USE THIS DIAGRAM FOR THE NEXT 4 QUESTIONS

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36. The above hydraulic circuit is a diagram of:

a. a sequence circuit
b. a counterbalance circuit
c. a pilot operated directional control circuit
d. a rapid traverse/feed circuit

37. In the above circuit, pressure control valve number 4 is used to:

a. close the check valve
b. sequence the cylinder
c. balance the load
d. set the feed speed

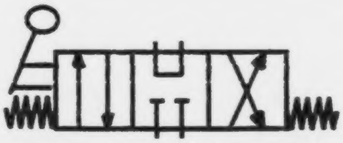
38. In the above circuit, if the cracking pressure on valve number four is set too low:

a. the cylinder will retract
b. the cylinder will extend
c. the check valve will open

39. In the above circuit, the cracking pressure of valve number 4 is determined by:

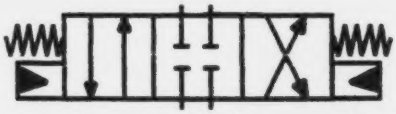
a. dividing the surface area of the piston end of the cylinder by the weight of the load.
b. dividing the weight of the load by the surface area of the piston end of the cylinder.
c. multiplying the weight of the load times the surface area of the piston end of the cylinder.

40. The below symbol is the symbol for a:



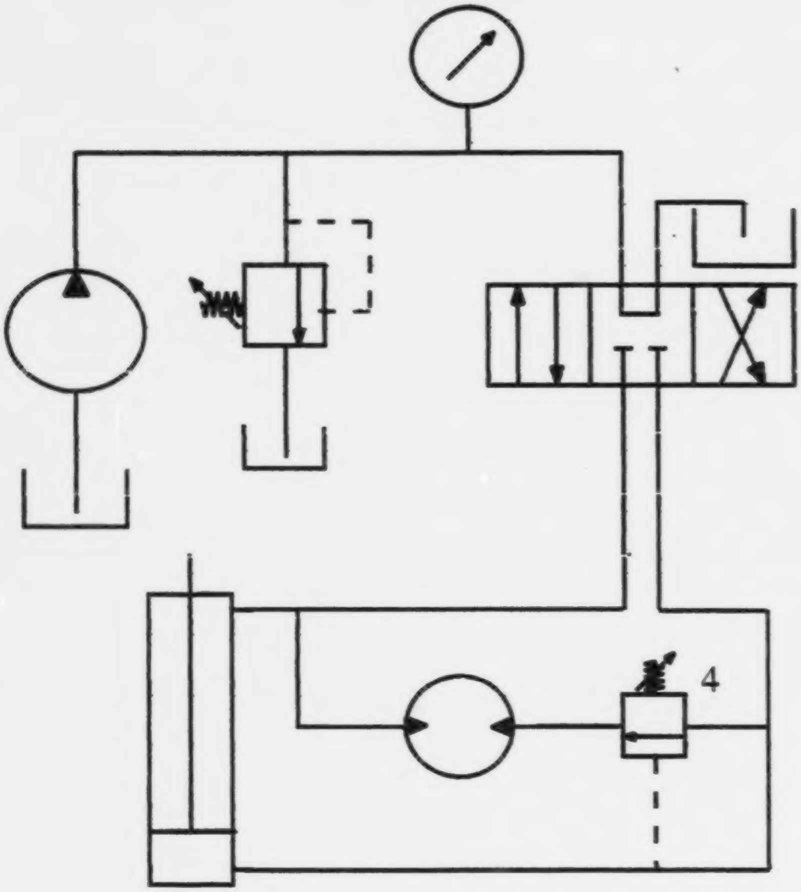
a. 2 way bi-directional valve, spring centered, pilot operated, open center
b. 4 way bi-directional valve, spring centered, manually operated, closed center
c. 4 way bi-directional valve, spring centered, manually operated, tandem center
d. 2 way bi-directional valve, spring centered, manually operated, tandem center

41. The below symbol is the symbol for a:



a. 4 way bi-directional valve, spring centered, pilot operated, open center
b. 4 way bi-directional valve, spring centered, pilot operated, closed center
c. 2 way bi-directional valve, spring centered, manually operated, tandem center
d. 4 way bi-directional valve, spring centered, pilot operated, tandem center

DO NOT WRITE ON THE EXAM!



USE THIS DIAGRAM FOR THE NEXT 3 QUESTIONS

42. The above hydraulic circuit is an example of:

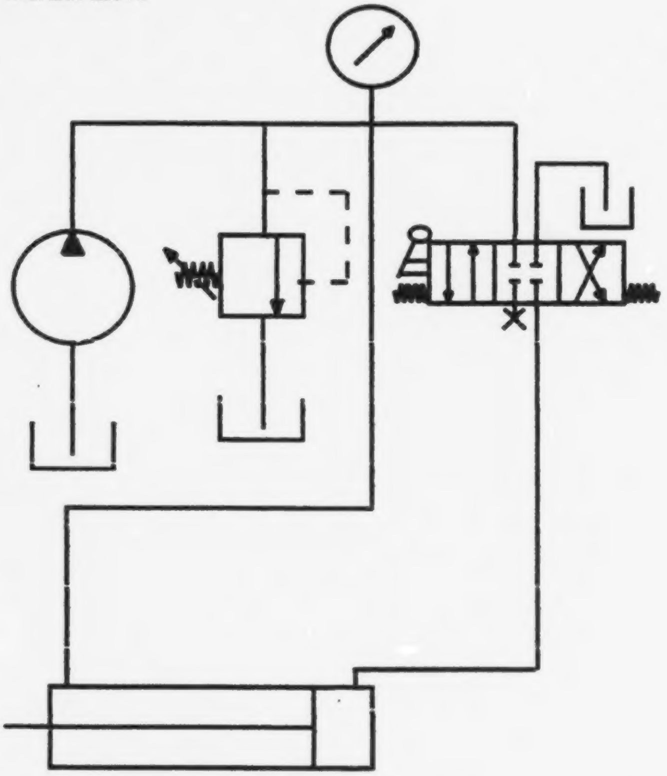
a. a sequence circuit
b. a rapid traverse/feed circuit
c. a regenerative circuit
d. a counterbalance circuit

43. In the above circuit, the hydraulic motor will run when:

a. at all times
b. the back pressure on the piston end of the cylinder exceeds the cracking pressure of valve 4
c. the back pressure on the rod end of the cylinder exceeds the cracking pressure of valve 4
d. it will never run

44. In the above circuit if the cracking pressure on valve 4 is set too low:

a. the motor will never run
b. the motor will run at the same time as the cylinder
c. the cylinder will not move



USE THIS DIAGRAM FOR THE NEXT 3 QUESTIONS

45. The above hydraulic circuit is an example of:

a. a sequence circuit
b. a counter balance circuit
c. a rapid traverse/feed circuit
d. a regenerative circuit

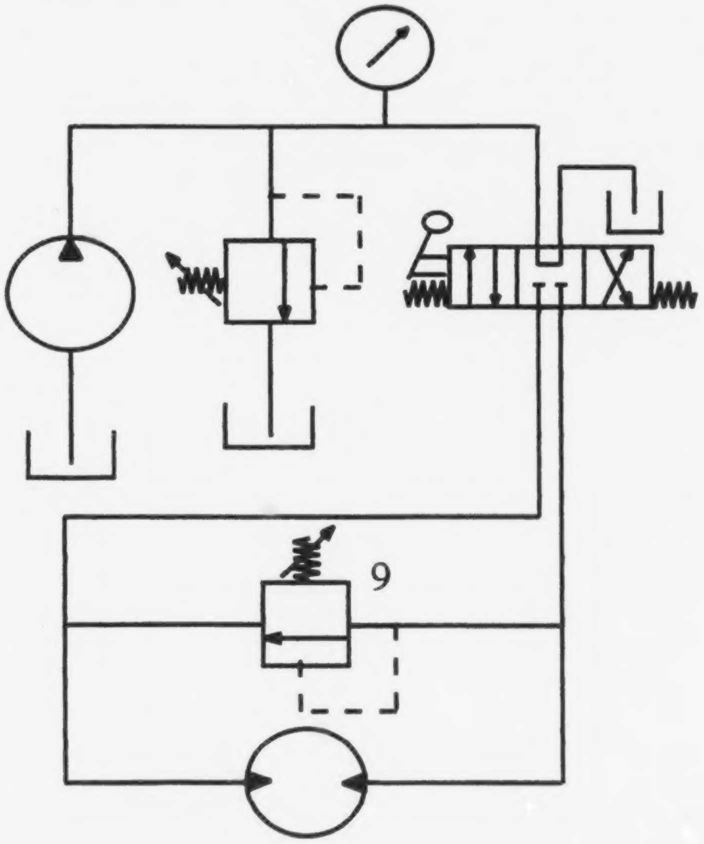
46. The purpose of the connection from the meter to the cylinder in the above circuit is to;

a. provide more pressure for the cylinder
b. decrease the speed of the cylinder
c. provide flow for the cylinder

DO NOT WRITE ON THE EXAM!

47. The above circuit works by:

a. providing more pressure for the cylinder
b. using the flow of oil from the rod end of the cylinder
c. using the flow of oil from the piston end of the cylinder
d. none of the above



USE THIS DIAGRAM FOR THE NEXT 3 QUESTIONS

48. The above hydraulic circuit is an example of:

a. a sequence circuit
b. a regenerative circuit
c. a counter balance circuit
d. a deceleration circuit

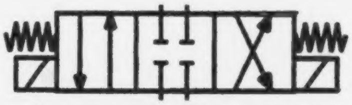
49. In the above circuit, valve number 9 is used to:

a. reduce the speed of the motor
b. increase the speed of the motor
c. prevent the motor from overshooting
d. prevent high pressure spikes in the system
e. c and d

50. Setting the cracking pressure too low on valve number 9 will

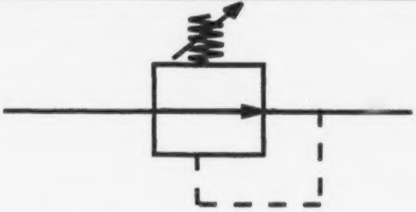
a. slow the motor
b. reduce the motor torque
c. make the motor run all the time
d. stop the motor

51. The below symbol is the symbol for a:



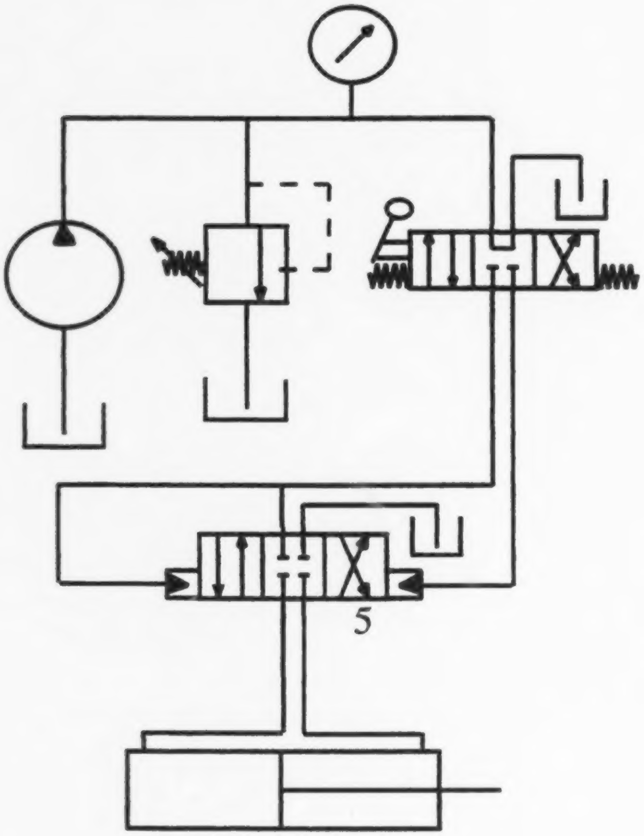
a. 2 way bi-directional valve, spring centered, pilot operated, open center
b. 4 way bi-directional valve, spring centered, manually operated, closed center
c. 4 way bi-directional valve, spring centered, solenoid operated, closed center
d. 2 way bi-directional valve, spring centered, solenoid operated, tandem center

52. The below symbol is the symbol for a:



a. pressure relief valve
b. sequence valve
c. pressure reducing valve

DO NOT WRITE ON THE EXAM!



USE THIS DIAGRAM FOR THE NEXT 2 QUESTIONS

53. The above hydraulic circuit is an example of:

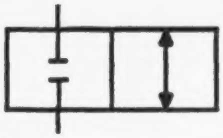
a. a regenerative circuit
b. a sequence circuit
c. a pilot operated directional control circuit
d. a counter balance circuit

54. In the above circuit valve 5 is operated by:

a. a solenoid
b. springs
c. pilot pressure
d. manually

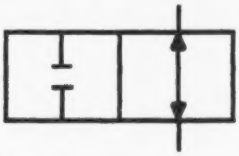
DO NOT WRITE ON THE EXAM!

55. The below symbol represents:



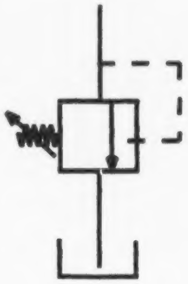
a. a normally closed 4 way valve
b. a normally open 2 way valve
c. a normally open 4 way valve
d. a normally closed 2 way valve

56. The below symbol represents:



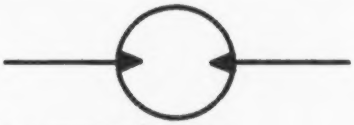
a. a normally closed 4 way valve
b. a normally open 2 way valve
c. a normally open 4 way valve
d. a normally closed 2 way valve

57. The below symbol represents:



a. pressure relief valve
b. sequence valve
c. pressure reducing valve

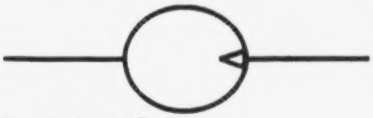
58. The below symbol represents:



a. a hydraulic pump
b. a pneumatic pump
c. a hydraulic motor
d. a pneumatic motor

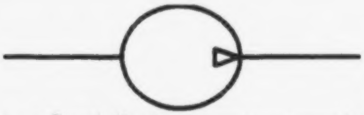
DO NOT WRITE ON THE EXAM!

59. The below symbol represents:



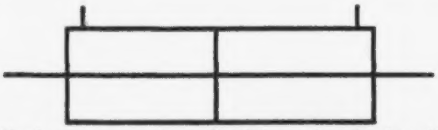
a. a hydraulic pump
b. a pneumatic pump
c. a hydraulic motor
d. a pneumatic motor

60. The below symbol represents:



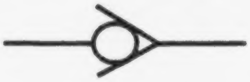
a. a hydraulic pump
b. a fixed displacement pneumatic compressor
c. a hydraulic motor
d. a pneumatic motor

61. The below symbol represents:



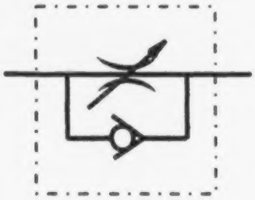
a. a single acting hydraulic cylinder
b. a double acting hydraulic cylinder
c. a double acting, double ended hydraulic cylinder

62. The below symbol represents:



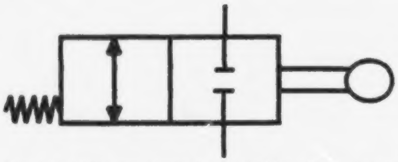
a. a flow control valve
b. a flow control valve with integral check valve
c. a check valve
d. a pressure compensated flow control valve

63. The below symbol represents:



a. a flow control valve
b. a flow control valve with integral check valve
c. a check valve
d. a pressure compensated flow control valve

64. The below symbol represents:



a. a 2 way normally open, mechanically operated on/off valve, spring return
b. a 2 way normally open, mechanically operated bi-directional valve, spring return
c. a 2 way normally closed, mechanically operated on/off valve, spring return
d. a 2 way normally closed, solenoid operated, on/off valve, spring return

65. True/false The speed of an actuator in a pneumatic system is determined by the pumping rate of the compressor.

a. true
b. false

66. The unloading valve in a compressor system is used to:

a. remove the pressure from the pneumatic system
b. unload the pressure reducing valve
c. remove the pressure from the head in a piston type compressor
d. none of the above

67. The heat exchanger in a compressor system is used to:

a. heat the air
b. allow the compressor to compress more air in the same volume
c. expand the volume of air
d. cool the compressor head

68. The drain valve in a pneumatic filter is used to:

a. remove air from the system
b. remove water from the system
c. remove dirt from the system
d. add lubrication to the system

69. Pressure regulation in a pneumatic system is usually accomplished by the use of:

a. a pressure relief valve
b. a pressure compensating valve
c. a pressure reducing valve
d. a flow control valve

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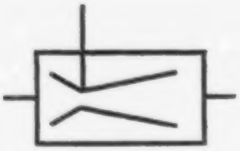
70. In a pneumatic system, control of actuator speed can only be accomplished by the use of a:

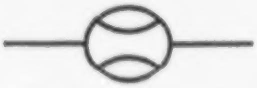
a. a pressure relief valve
b. a pressure compensating valve
c. a pressure reducing valve
d. a flow control valve

71. The below symbol represents:



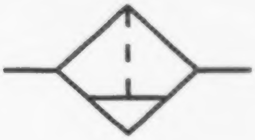
a. a flow meter
b. a filter
c. a venturi
d. a separator

72. The below symbol represents:



a. a flow meter
b. a filter
c. a venturi
d. a separator

73. The below symbol represents:



a. a flow meter
b. a filter with manual drain
c. a venturi
d. a filter/separator with manual drain

74. True/false a pneumatic cylinder can be used to lock the position of a load.

a. true
b. false

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75. The absolute pressure at the restriction of a venturi is;

a. atmospheric pressure
b. one bar
c. lower than atmospheric pressure
d. higher than atmospheric pressure

76. True/false. When the acuator flow is set to a constant value, changing the pressure of a pneumatic system varies the rate of flow to the actuator.

a. True
b. False

77. True/false. Changing the pressure of a hydraulic system varies the rate of flow to the actuator.

a. True
b. False

78. True/ false. In both a hydraulic and pneumatic system, increasing the cross sectional area of the tubing results in a larger pressure drop across a length of tubing.

a. True
b. False

79. True/ false. In both a hydraulic and pneumatic system, increasing the length of the tubing results in a larger pressure drop across the length of tubing.

a. True
b. False

80. In a meter-in hydraulic or pneumatic circuit, the flow control is:

a. controlling the flow into the actuator
b. controlling the flow out of the actuator
c. controlling the pressure out of the actuator.
d. none of the above

81. In a meter-out hydraulic or pneumatic circuit, the flow control is:

a. controlling the flow into the actuator
b. controlling the flow out of the actuator
c. controlling the pressure out of the actuator.
d. controlling the pressure into the actuator

82. SCFM stands for:

a. Semi-Compensated Filter Mechanism
b. Standard Cubic Feet per Minute
c. Square Cubic Feet per Minute
d. Standard Cubic Feet per Hour

83. A hydraulic pump has a displacement of 1 cubic inch per revolution, it is driven by a synchronous inductive motor which runs at 1800 RPMs. If the slip rate of the inductive motor is 10 percent, the pump has a flow rate of: (round off to nearest whole number)

a. 18 GPM
b. 10 GPM
c. 7 GPM
d. 8 GPM

84. SUS stands for:

a. Standard Uniform Section
b. Suction Under System
c Saybolt Uniform Section
d. Saybolt Universal Seconds

85. SUS is a measure of:

a. pressure
b. displacement
c. viscosity
d. flow

86. True/false It is permissible to charge an accumulator with compressed air.

a. True
b. False

87. True/false The stored volume of oil in an accumulator changes with the system pressure.

a. True
b. False

88. The heat generated in a hydraulic system is a function of:

a. pressure
b. flow
c. both pressure and flow

89. An accumulator can be used to:

a. even out pressure variations
b. act as an emergency source of energy
c. increase the efficiency of a pumping system.
d. all of the above

90. True/false A check valve can be used on the inlet line of an accumulator.

a. True
b. False

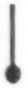
91. True/false A dump valve should be used on an accumulator circuit to relieve system pressure.

a. True
b. False

92. The inlet side of any pump should be:

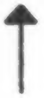
a. atmospheric pressure
b. higher than atmospheric pressure
c. lower than atmospheric pressure
d. none of the above

93. In a hydraulic or pneumatic system, the below symbol represents:



a. pressure compensation
b. flow compensation
c. temperature

94. In a pump or valve, the below symbol represents:



a. pressure compensation
b. flow compensation
c. temperature

95. In a pneumatic system, the pressure of a given amount of air _________ with increasing temperature.

a. decreases
b. increases

96. A cylinder with a 10" bore and a 24" stroke must move a 1000 pound load through its stroke in 2 seconds. How much hydraulic horsepower is required to move the cylinder?

a. approximately 10 hp
b. approximately 4 hp
c. approximately 2 hp
d. approximately 1 hp

97. If a pneumatic tank can contain 20 cubic feet of air at a pressure of 100 psig and a temperature of 70 degrees Fahrenheit, what is the pressure in the tank if the temperature of the air is reduced to 60 degrees Fahrenheit?

a. approximately 120 psig
b. approximately 74 psig
c. 20 psig
d. 100 psig

98. The major types of pumps are:

a. piston pumps
b. vane pumps
c. gear pumps
d. centrifugal pumps
e. all the above

99. A hydraulic intensifier works on the principle of:

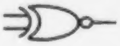
a. horsepower
b. F=P*A
c. flow
d. volume

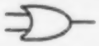
100. A 10 micron filter in a hydraulic system will block any particle larger than:

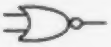
a. . 254 inch
b. . 0039 inch
c. . 00039 inch
d. . 000039 inch

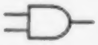
Final Exam, Manufacturing Technology 215 -Digital Electronics

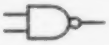
Identify the symbol for the following gates

a. 

b. 

c. 

d. 

e. 

1. AND gate

2. OR gate

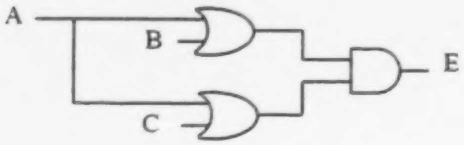
3. NAND gate

4. NXOR gate

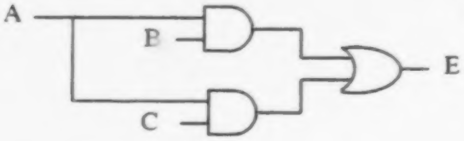
5. NOR gate

Identify the gating structure for the following Boolean expressions

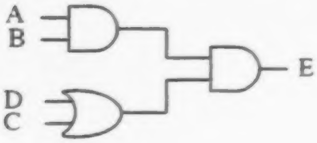
a.



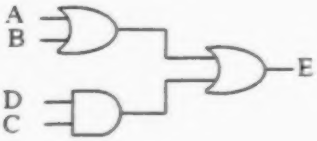
b.



c.



d.



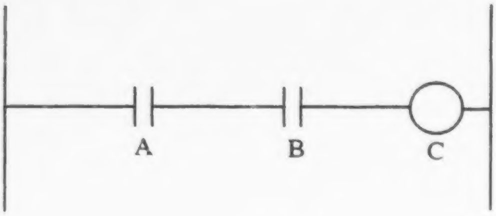
6. A * B + A * C = E

7. A + B + C * D = E

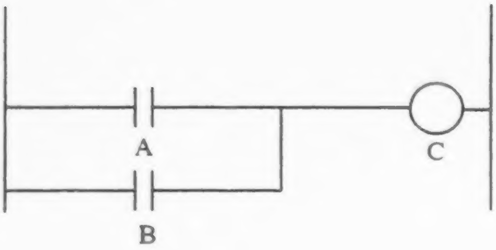
8. A + B * A + C = E

9. A * B * C + D = E

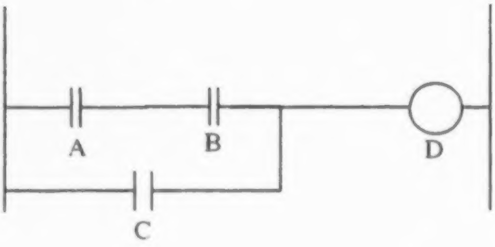
Identify the ladder diagram logic for the following gating structures.



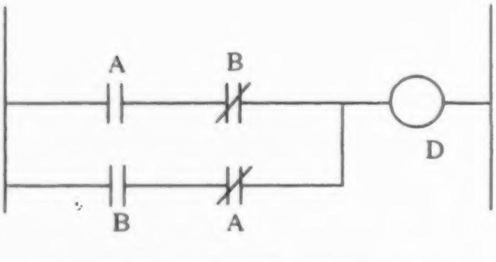
a.



b.



c.



d.

10. A $\oplus$ B = D

11. A * B = C

12. A + B = C

13 A * B + C = D

14. Multiple choice A binary counter can be used as:

a. a first in first out register
b. a last in last out register
c. a device to count in binary and provide multiple frequencies
d. a binary adder

15. Multiple choice In a binary ripple counter, when the counter has a full count, the next count pulse will reset the flip/flops:

a. all at once
b. sequentially
c. will not reset the flip/flops at all

16. Multiple choice The output of the first flip/flop in a binary counter will divide the input clock frequency by:

a. 1/2
b. 1/4
c. 1/8
d. 1/16

17. Multiple choice A totem pole output for a TTL gate is a logical one when the output voltage is greater than:

a. one volt
b. 0 volts
c. 2 volts

18. Multiple choice In a totem pole output for a TTL device, a voltage of 1.5 volts is:

a. a logical 1
b. a logical 0
c. in the forbidden region

19. True/False Fan-out refers to the number of inputs that a TTL output can drive.

a. True
b. False

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20. Multiple choice In a TTL totem pole output the transistor that is connected to the +5 volt supply is known as the ___________ transistor, and the transistor connected to common is know as the ________ transistor.

a. source, sink
b. sink, source

21. Multiple choice: TTL means:

a. Transistor Threshold logic
b. Transistor, transistor, logic
c. Three state logic

22. True/False: A R-S latch flip/flop operates on an AC transition.

a. true
b. false

23. True/False: A one-shot multivibrator is an example of a bi-stable multivibrator.

a. True
b. False

24. True/false: A four bit decade counter counts up to 15 and then counts to zero.

a. true
b. false

25. Multiple choice A binary to seven segment decoder/driver converts binary to:

a. decimal
b. readout segments
c. octal
d. hexadecimal

26. Multiple choice In a decimal to binary decoder, the inputs are _____ numbers and the outputs are _______ numbers

a. binary, decimal
b. decimal, binary
c. BCD, decimal
d. decimal, BCD

27. Multiple choice When testing a microprocessor for proper operation, two of the main items that should be tested are:

a. the condition code register and the program counter
b. the power supply voltage and the clock
c. the disk drive and the keyboard

28. Multiple choice When testing the microprocessor's address bus and data bus, the effort is to look for:

a. stuck bits (either high or low)
b. actual addresses
c. actual data

29. True/False A PIA or UART cannot stop the microprocessor from working.

a. true
b. false

30. True/False To the microprocessor, a PIA or UART is indistinguishable from memory.

a. true
b. false

31. Multiple choice: An open collector output module for a PLC requires:

a. a connection to source voltage
b. a connection to source voltage in series with a solenoid, relay or other device
c. a connection to machine ground
d. a connection to common in series with a solenoid, relay or other device

32. Multiple choice: When starting a newly installed PLC system:

a. disconnect all motion causing devices
b. remove all input and output modules
c. remove all fuses
d. remove the CPU

33. Multiple choice: When starting a newly installed PLC system:

a. check for proper wiring of the master control relay
b. check all input and output wiring
c. check all power supply and common connections
d. all the above

34. Multiple choice: When starting a newly installed PLC system, to check out the operation of input and output modules, ______ the modules using the ______.

a. inspect, microscope
b. force, HHT
c. measure, ohmmeter
d. remove, screwdriver

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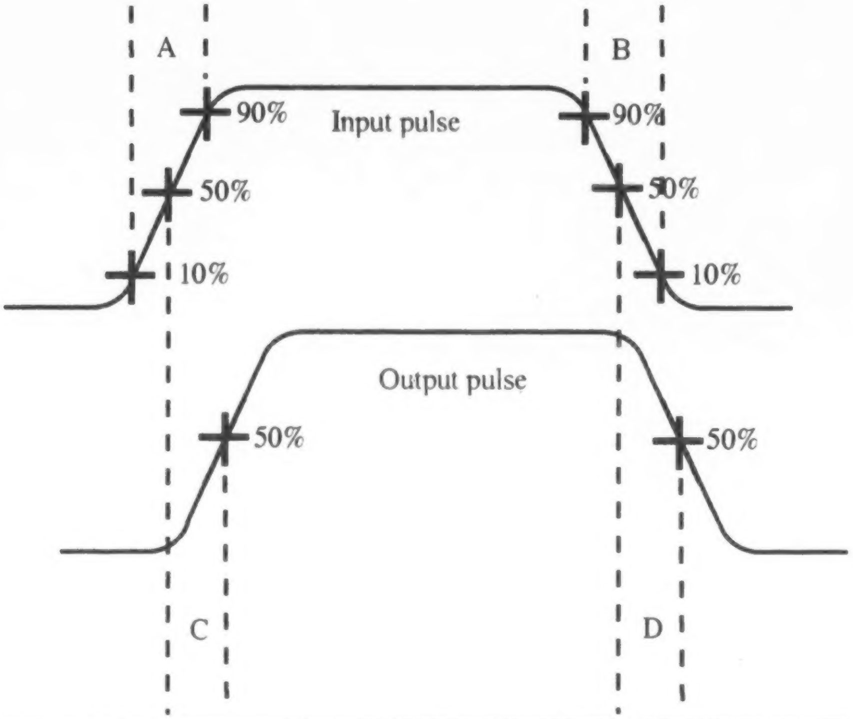
35. In the diagram below, the rise time of the signal, low to high, is depicted by the letter:

a. A
b. C
c. B
d. E


A
B
90%
Input pulse
90%
50%
50%
10%
10%
Output pulse
50%
50%
C
D

36. In the diagram above, the propagation delay time high to low is depicted by the letter:

a. A
b. C
c. B
d. E

37. In the diagram above, the fall time of the signal, high to low, is depicted by the letter:

a. A
b. C
c. B
d. E

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38. Multiple choice: When starting a newly installed PLC system, one of the first steps is to _____ the ______

a. inspect, CPU
b. program, HHT
c. measure, output
d. configure, PLC

39. Multiple choice: To properly _______ the PLC you need to know _______.

a. inspect, the CPU
b. configure, the CPU model number
c. measure, output
d. program, C++

40. Multiple choice: To properly _______ the PLC system you need to know _______.

a. inspect, the CPU
b. configure, PASCAL
c. configure, module model numbers
d. program, BASIC

41. Multiple choice: To properly _______ a PLC you need to understand _______.

a. inspect, the CPU
b. program, Boolean algebra
c. measure, transistor
d. program, C++

42. Multiple choice: When troubleshooting a new installation, if your input circuit LED is on and the input device is on/closed/activated, and your input device will not turn off, then the most probable cause is:

a. Input is forced off in program
b. device is shorted or damaged
c. Input circuit is damaged
d. input device is open or damaged

43. Multiple choice: When troubleshooting a new installation, if your input circuit LED is off and the input device is off/open/deactivated, and your input device will not turn on, then the most probable cause is:

a. Input is forced off in program
b. device is shorted or damaged
c. Input circuit is damaged
d. input device is open or damaged

44. Multiple choice: When troubleshooting a new installation, if your input circuit LED is off and the input device is on/closed/activated, and your program acts as though the input device will not turn on, then the most probable cause is:

a. low voltage from the input
b. incorrect wiring or an open circuit
c. Input circuit is damaged
d. input circuit is incompatible with the device
e. all the above

45. Multiple choice: When troubleshooting a new installation, if your input LED is on and the input device is off/open/deactivated, and your program acts as though the input device will not turn off, then the most probable cause is:

a. low voltage from the input
b. incorrect wiring or an open circuit
c. Input device off-state leakage current exceeds input circuit specification
d. input circuit is off
e. all the above

46. Multiple choice: When troubleshooting a new installation, if your output LED is on and the output device is on, and your program acts as though the output device should be off, then the most probable cause is:

a. low voltage from the output
b. incorrect wiring or an open circuit
c. Input device off-state leakage current exceeds input circuit specification
d. input circuit is off
e. programming problem

47. Multiple choice: When troubleshooting a new installation, if your output LED is off and the output device is off/deactivated, and your program acts as though the output device should be on, then the most probable cause is:

a. programming problem
b. output is damaged
c. output is forced off
d. all the above

48. Multiple choice: When troubleshooting a new installation, if your output LED is on and the output device is off/deactivated, and your program acts as though the output device should be on, then the most probable cause is:

a. low voltage from the input
b. incorrect wiring of open collector circuit
c. Input device off-state leakage current exceeds input circuit specification
d. output circuit is forced off
e. programming problem

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49. Multiple choice: When troubleshooting a new PLC installation, if the power LED on the CPU module is on, and the CPU FAULT LED is flashing:

a. the CPU module is bad
b. the power is bad
c. the CPU is bad
d. the processor memory needs to be cleared

50. Multiple choice: In addition to inputs and outputs, a PLC contains:

a. software inputs
b. software outputs
c. timers
d. counters
e. all the above

51. True/false: Timers and counters have contacts associated with them that can be used like real inputs.

a. true
b. false

52. Multiple choice: Refer to ladder diagram 1. The Boolean statement for rungs 1 and 2 is:

a. PB1*MCR+EMS*PB2=MCR
b. (PB1+MCR)*EMS*NOT PB2=MCR
c. PB1+(MCR+EMS)*NOT PB2=MCR
d. (PB1+MCR)*EMS*PB2=MCR

53. Multiple choice: Refer to ladder diagram 1. The Boolean statement for rungs 4, 5 , and 6 is:

a. (RDY*SERV)+(LSOVR*LS-2)+SEVFLT*EMS=CR1
b. RDY+SERV+NOT LSOVR*LS-2+SEVFLT*EMS=CR1
c. RDY*(SERV+NOT LSOVR)*(NOT LS-2+SEVFLT)*EMS=CR1
d. (RDY*SERV)+(NOT LSOVR*LS-2)+SEVFLT*EMS=CR1

54. Multiple choice: Refer to ladder diagram 1. The Boolean statement for rungs 8 and 9 is:

a. (NOT CR1*NOT SERVFLT)+SERV*SERVOK=SERV
b. (NOT CR1*NOT SERVFLT)+NOT SERV*SERVOK=SERV
c. (NOT CR1+NOT SERVFLT)*SERV+SERVOK=SERV
d. (CR1*SERVFLT)+SERV*SERVOK=SERV

55. If the external emergency stop contacts are not operated, wire 4 will be:

a. energized
b. de-energized

56. If the external emergency stop contacts are operated, and PB-1 is closed, wire 4 will be:

a. energized
b. de-energized

57. If the external emergency stop contacts are not operated, and PB-1 is closed and released, wire 4 will be _______ by _______:

a. energized, EMS
b. de-energized, PB-1
c. energized, MCR
d. de-energized, MCR

58. If the SERVOK contacts close, and CR1 output is not energized, and the RDY contacts are closed, then ____ will energize, and SERV will _____ by the _____ contacts

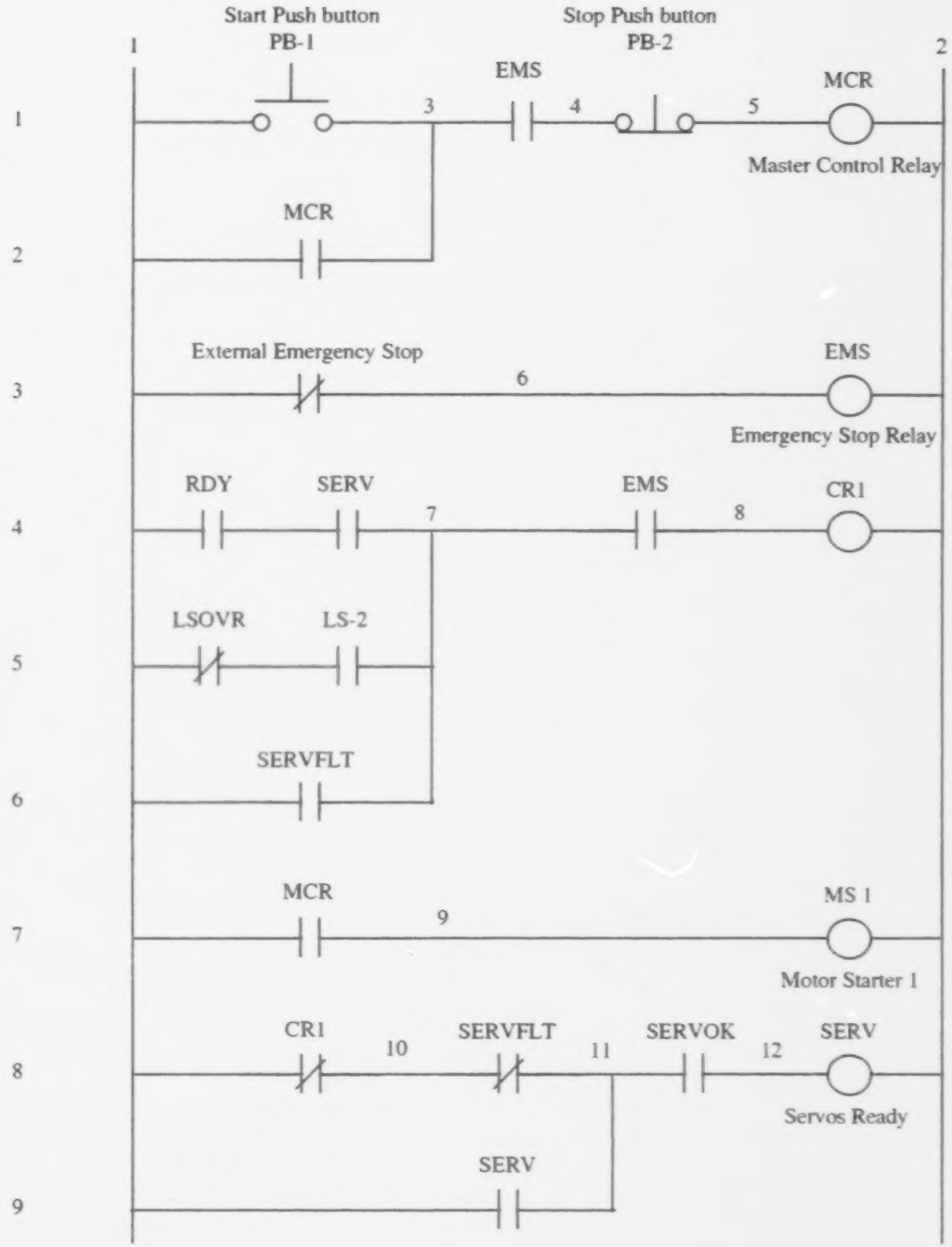
a. EMS, de-energize, SERVOK
b. CR1, energize, SERV
c. MS-1, de-energize, CR1
d. SERV, de-energize, CR1

59. If the MCR output is energized, and PB-2 is pressed, wire 3 will be:

a. energized
b. de-energized

60. CR1 will energize whenever:

a. RDY and SERV are true
b. NOT LSOVR and LS-2 are true
c. SERVFLT is true
d. all the above


Start Push button
PB-1
Stop Push button
PB-2
1
2
EMS
MCR
1
3
4
5
Master Control Relay
MCR
2
External Emergency Stop
EMS
3
6
Emergency Stop Relay
RDY
SERV
EMS
CR1
4
7
8
LSOVR
LS-2
5
SERVFLT
6
MCR
MS 1
7
9
Motor Starter 1
CR1
SERVFLT
SERVOK
SERV
8
10
11
12
Servos Ready
SERV
9

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